

**THE AMERICAN CIVIL WAR AND
MILITARY TECHNOLOGICAL CHANGE**

DOCTORAL THESIS

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Obviously, despite all the support received, responsibility for the selection of the materials and the treatment of the topic is entirely my own.

For the record as well, this thesis contains no material which has been submitted for the award of any degree or diploma in any university or college and to the best of my knowledge and belief the thesis contains no copy or paraphrase of material previously written or published by another person unless I have made acknowledgement in the text of this work.

Marcus Bowles

Military technology change is a subject of enormous diversity and profound complexity. To reduce the topic to some ordered form the thesis discusses military technological changes in one period; the American Civil War from 1861 to 1865.

The thesis also contends that military technology cannot be studied in purely physical terms. Only in conjunction with environmental elements can we fully comprehend technical change. This will enable us to make sense of technology as both a technical entity constructed from existing scientific knowledge, and as a human activity interacting with the surrounding environment.

The thesis argues that during the war it was possible to establish how non-technical factors concentrated development on traditional weapons technology. Subsequently, technical growth was mainly low risk, cumulative, and based on established technology. Over five years, however, wartime innovations still produced significant advances in technical knowledge. The ultimate success of changes to wartime military technology can therefore be understood by using innovation as a guide. From such a basis one can progress beyond the examination of an individual entity, to also assess the overall innovation process within which technological development occurred.

The inquiry leads to an open questioning of existing approaches' ability to fully gauge Civil War military technological change. Popular theories, explaining scientific discovery, fail to provide an appropriate methodological approach by which this thesis may be pursued. Equally, the question of the growth to 'modern war' is addressed early in the thesis. This is done to illustrate the need for a more accurate yardstick that can provide a basis of comparison with 'modern war'.

The thesis concludes that study of Civil War innovations can provide the tool with which to identify and assess military technological change.

The thesis will be able to highlight that, despite military technological growth being predominantly made by small incremental changes, it nevertheless altered the technical knowledge available to innovators. By identifying the cumulative advances in technical hardware it is possible to illustrate how significant the changes to some military technologies were, when compared to the advances attained prior to the Civil War.

It is the identification of non-technical elements, affecting the development of Civil War innovations, that permits the thesis ultimately to make sense of the direction, and the incremental advance of Civil War technical change.

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ABBREVIATIONS

ACW	American Civil War
CBO	Confederate (Army) Bureau of Ordnance
CS Army	Confederate States Army
CSAMD	Confederate States Army Medical Department
CSN	Confederate States Navy
CSS	Confederate States Steamer
Cwt	Hundred Weight (112 pounds)
BLR	Breech Loading Rifle
BLSB	Breech Loading Smooth Bore
HE	High Explosive
In	Inch
How	Howitzer
M	Model
MLR	Muzzle Loading Rifle
MLSB	Muzzle Loading Smooth Bore
MTB	Motor Torpedo Boat
Pd	Pounder
US	United States
US Army	United States Army
USAMC	United States Army Medical Corps
USCE	United States Corps of Engineers
USMTC	United States Military Telegraph Corps
USMRD	United States Military Railroad Department
USOB	United States Ordnance Bureau
USN	United States Navy
USQMC	United States Quartermaster Corps
USS	United States Steamer
USSC	United States Signal Corps
SCA	Self Contained Ammunition

INTRODUCTION

The study of military technological change is entangled with contemporary concerns;(1) it is embodied in any study of the growth to modern war as we recognize it today. To understand questions arising from measuring military technological change is enormously complex and must require some form of ordering before it may be properly conducted. In the first instance this will be done by concentrating upon the American Civil War because it can be seen to lie at the chronological centre of the historical debate over the change from traditional warfare to modern conflict. Secondly, technology will not be examined as just a physical entity, but more completely as a function within a wider environment.

The claim that military technological change is central to the study of the evolution of modern warfare would surprise few. In tying this thesis to an examination of technological change to the Civil War a secondary debate will be initiated on the war's role in the evolution to warfare as we know it in the twentieth century.

Throughout history there has been a direct relationship between the way wars are waged and the the rapidity of changes to existing military technology. The knights' supremacy on the battlefield was firstly challenged by the long bow at the battle of Crecy, and later by early fourteenth century advances in firearms. During the nineteenth century the history of warfare may be divided into distinct phases of growth in technology. The dominance of the flintlock, and wood and sail continued from 1800 until around 1840. The factory age from 1840 till 1870 saw percussion caps, naval shells and breech-loading rifled (BLR) cannons, ironclad warships, steam propulsion, and better communication systems. Then finally, up to the end of the century, a period of faster development occurred. This centred on machine guns and rapid fire small arms, smokeless powder, better BLR cannon designs, the super-heavy gun, motor vehicles, the submarine, and sea-going ironclads.(2)

The American Civil War from 1861 to 1865 stands at the mid-point of military technological evolution in the nineteenth century. The war occurred at a point in time that lay between the initial period where industrialization increased the available means to produce new technical entities, and the early twentieth century landmark of modern war and mass destruction; the First World War.

The examination of key technological changes to the Civil War has promoted a surprising polarisation of belief on the war's modern dimensions. Study has mainly

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1. H.S. Commager, *The Blue & the Grey* (Vol.I) (Indianapolis, Bobbs, 1950:xv)
 2. see M. Glover, *Warfare from Waterloo to Mons* (London, Cassell, 1980:7)

concentrated on the important steam innovations – the railroads and ironclad warships – and noted the importance of telegraphic and balloon innovations.

It would, however, be an oversimplification to assume that the progress of warfare may be mapped by solely concentrating on the series of breakthrough technologies that provided the tools for the twentieth century wars of mass destruction. Technologies that are widely held to be significant technical advances, like the ironclad Monitor, the Gatling Gun, or the Henry repeating rifle, do not seem to provide clear milestones in the evolution of military technology. None of these innovations can be divorced from technical knowledge existing prior to the Civil War.

New technological entities are mostly the result of cumulative advances in technical knowledge. Identification of all the pre-existing sources from which inventors drew to produce these novel designs is almost impossible. Thus, it is necessary to realize that the study of a few technological entities, cannot show a clear progression in all military technical knowledge, from the beginning to the end of the nineteenth century.

To fully comprehend military technological change it is necessary to avoid the narrow emphasis on just a physical innovation. Consideration also needs to be given to the individual actor who:

...as a human being who has emotions, conflicts, inconsistencies, and who does not live in a social vacuum but rather mediates between the wider socio-political and cultural context and the kind of science which results from it.(3)

A study that includes the human element of technical development becomes more than an internal focus on the end product as a part of the wider body of scientific knowledge. Rather, it accepts that technology occurs as a function within a wider environment. As such, there is a need for an external assessment of the environmental influences on technical change.(4) Only by uniting these two dimensions together may we comprehend what body of knowledge the identified technology built upon, its contribution to technical development, and once introduced, its impact on a given social environment.(5)

The examination of human factors necessitates the consideration of variables, other than just technical concerns, that may affect military technological change. For example, understanding the technical history of the Martini–Henry rifle could not hope

3. I. Spiegel–Rosing, "The Study of Science, Technology & Society" in I. Spiegel–Rosing & D. De Solla Price (ed), Science, Technology & Society (London, Sage, 1977:20)

4. T.S. Kuhn, "The History of Science", International Encyclopedia of the Social Sciences (No.14, 1968:80–81)

5. J.J. Salomon, "Science Policy Studies & The Development of Science Policy" in Spiegel–Rosing & De Solla Price, Science, Technology & Society (1977:49)

to explain adequately how Zulus armed with assegai, overcame the British at Isandhlawana in 1879;(6) or how poor tactical choice, by having Confederate forces charging across open ground at the "Hornets Nest" in the Battle of Shiloh, contributed more to the massive casualties than any improvement in Federal firepower.(7) Unlike a study of purely technical matters a human approach to explaining technological change invites consideration of wider elements. These include battlefield terrain, organizational efficiency, strategy, and other non-technical factors that give a more complete picture of influences on the advancement in military design.

Using a humanistic analysis of military technological change enables the re-evaluation of some characteristics of modern warfare. Writing in the early part of the nineteenth century Carl Von Clausewitz established a doctrine of 'nation-in-arms' in which he advocated that the maximum fighting power of any nation had to be mobilized to win future wars.(8) This 'absolute war' or 'total war' required that political, socio-economic, and military force, be combined to provide a potent means to carry out strategic policy.

With the development of rail and telegraph, and improved organization of military supply, mass armies of the mid- to late nineteenth century were able to be moved in great numbers, and swiftly concentrated on areas of the battlefield. This was a type of war unlike previous wars. It required a new dimension: industrial might, and the commitment of society, and especially its government, to sustain military effort. This commitment to supply advanced technology to the military, surpassed traditional experiences of 'limited' wars.(9)

The limited war concept has been used to help identify the difference from the total wars of later years. Here limited interests, limited objectives, and the restricted time and geographic space of conflict, involved less sustained strategic operations.(10) In contrast, modern military technology is developed to satisfy specific strategic requirements. The First World War provided the consolidation point for the industrial

6. R. Holmes, The World Atlas of Warfare: Military Innovations that Changed the Course of History (London, Guild Publishing, 1988:7)

7. J. MacDonald, Great Battles of the American Civil War (London, Guild Publishing, 1988:26-27)

8. R.A. Leonard, A Short Guide to Clausewitz On War (London, Weidenfeld & Nicolson, 1967:25); & C. Von Clausewitz, On War (London, Penguin, 1984:401-410)

9. See G. Parker, The Military Revolution: Military Innovation & the Rise of the West 1500-1800 (Cambridge, Cambridge University Press, 1988:esp.1-7)

10. D.G. Chandler, Atlas of Military Strategy: The Art, Theory & Practice of War, 1618-1878 (London, Arms & Armour, 1980:128-129), K. Macksey, Technology in War: The Impact of Science on Weapon Development & Modern Battle (London, Arms & Armour Press, 1986:12-13); & A. Jones, "Jomini & the Strategy of the American Civil War, A Re-interpretation", Military Affairs (Vol.34[4], December 1970:127-128)

age's knowledge and power.(11) Here it was shown that under the sponsorship of the State the process of military technological change could be harnessed to achieve set ends.

It is important to note that despite varying definitions of limited and total war, the Civil War has not conclusively been designated as belonging to either category. At one extreme, scholars examining military technological innovation have come to the conclusion that the Civil War was not the scene for any significant changes. So not only was the war based on pre-existing technology and related strategy, but also, was still a war fought in the "traditional" vein of nineteenth century wars.(12)

Others take the opposite view, arguing that the Civil War can in no way be considered "traditional". They point to changes to military technology as the greatest indication in favour of their argument that the war was unlike all before it, and more akin to those that were to follow in the next century.(13)

Some analysts of the Civil War have been satisfied to call it the "first modern war" purely because of the volume of technical innovation which occurred. These writers examined weapons in isolation, and labelled the Civil War as the first 'modern' conflict purely because some weapons were to be used in wars of the twentieth century.(14)

This thesis does not accept that just because there occurred novel or new military weapons, ideas, or designs, that the Civil War is automatically distinctly unlike previous "traditional wars". Nor, if the war can be shown as possessing some features of 'modern wars', does it suggest that all wars from 1865 were modern in proportion.

Nevertheless, there are significant features of the Civil War that indicate it had aspects of total commitment. These include commitment of industrial capacity, exploitation of natural resources, utilisation of the fruits of the industrial and scientific revolution, utilization of innovations in steam technology, electric telegraph, breech-loading weapons, repeating small arms, and torpedoes and related torpedo delivery systems.

11. M. Howard, "War & Technology", *RUSI* (Vol. 132[4], December 1987:20)

12. A. Hunter-Dupree, Science in the Federal Government: A History of Policies & Activities to 1940 (Massachusetts, Harvard University Press, 1957:125); J.M. McPherson, Ordeal By Fire (New York, Alfred A. Knopf, 1982:180); Glover, Warfare from Waterloo to Mons (1980:103); & P. Griffith, Rally Once Again (Wiltshire, Crosswood Press, 1987:189)

13. E. Hagerman, The American Civil War and the Origins of Modern Warfare (Bloomington, Indiana University Press, 1988:xvii); I.B. Cohen, "Science & the Civil War", Technology Review (Vol.48, 1946:193); W. Millis, Armies & Men: A Study in American Military History (London, Jonathan Cape, 1958:121-122); F.A. Shannon, The Organization & Administration of the Union Army (Vol.I) (Massachusetts, Peter Smith, 1965:142-143); W.H. McNeill, The Pursuit of Power: Technology, Armed Force & Society Since AD 1000 (Oxford, Basil Blackwell, 1983:242); & C.L. Davis, Arming The Union (Port Washington, Kennikat Press, 1973:165 & 178)

14. Macksey, Technology in War (1986:31)

Finally there was also experimentation on innumerable novel weapons and production techniques.

These factors when studied together seem to contrast with the common features of what has been labelled limited warfare. Yet behind these technical developments was the maintenance of limited government intervention: a lack of societal support, particularly in the Union from 1863, for the objectives of the war; and the wide deployment of traditional technology such as smooth-bore cannon and muskets. Compounding these decidedly traditional factors, military demand was so uncertain it promoted a lack of focus from industry on the production of new military technology.

It is the debate over the Civil War's status as the first 'modern war' that highlights the need to establish how military technological change in the 1861 to 1865 period, as distinct from other periods, may be measured. Thus while this thesis is not about deciding whether the Civil War was the first modern war, it will be necessary, at the most fundamental level for the study to produce a theoretical framework capable of explaining military technological change, and focussing research onto the complex question of its modernity.

CHAPTER 1: MILITARY TECHNOLOGICAL CHANGE AND THE CIVIL WAR

Before formulating an approach to establish military technological growth in the Civil War there has to be some justification for the approach to be used in this thesis. There firstly will have to be an examination of the material available for study of the Civil War. Then an understanding of military technological change will need to be conceived. Only then will it be possible for the methodology, appropriate for this thesis, to be outlined.

It needs to be acknowledged that certain difficulties arise for a thesis that is written outside the United States, and away from the heart of current academic debate on the Civil War. These difficulties are compounded by the academic attention the topic has elicited.⁽¹⁾ However, an outside study can bring closer understanding of the war's international legacy and perhaps add a new angle to the more traditional studies of the Civil War.

Undoubtedly the existing labyrinthine proportions of the resource material make it difficult to consult all relevant sources. Therefore, the most obvious restriction placed on this work has been the necessity to fully establish the limits to the discussion that will be carried out. Within the first chapter a deliberate attempt has been made to place this thesis into context with those relevant academic studies already in existence.

1.1 Historiography of the Civil War

Since the American Civil War has enjoyed 125 years of intense research it is impossible for this section to do more than cover the essential works affecting a study of military technological change.⁽²⁾

The assessment of the Civil War has held a pervading interest for those who have sought to understand the basis for the modern American nation. However, this thesis is *not* directly assessing the Civil War. Rather, it is seeking to understand military technological change to the Civil War setting. As such the study will of necessity recover material already written on the Civil War. This makes an historiographical

1. 520 titles that have been published on the topic since 1986, Australia Review Section (13-14 October 1990:6)

2. A recent assessment by the Bulletin magazine in Australia estimated that some 50,000 major works have been written on the Civil War; Abraham Lincoln alone allegedly having more works written in English on him than anyone except Shakespeare and Christ. (October 2, 1990:76); This problem was also noted by T.J. Pressly, Americans Interpret Their Civil War (Princeton, Princeton University Press, 1954:xi); & C.W. Ramsdell, "The Changing Interpretation of the Civil War", Journal of Southern History (Vol.3, February 1937:3)

summary important because it can provide both a synopsis of the arguments bearing on this study, and establish any existing historical matter that this thesis may build upon.

General historical studies have provided a myriad of secondary information, interpreting original sources from the Civil War: personal diaries, specific studies of battles (large and small), regimental histories, and so on. To ease the analysis of material written on the war, three broad categories of writings may be identified.

The first period encompasses the first fifty years from 1861 to 1911. Writings in this period included works of primary importance. Contemporary writers drew upon their immediate experiences to examine the war. The period also is marked by the publication of works by foreign writers examining the international legacy of the war.

The next phase of analysis, stretches for another fifty years from 1911 to 1961. Marked by two world wars and an increase in international military conflict, writers in this period interpreted the Civil War in the reflected light of these new experiences.

The third period stretches from 1961 until the present day. In effect this period started with the spur Civil War centenary celebrations engendered in the American academic world. It is marked by a growing maturity, with the period from 1986 till 1990 (the period over which this thesis was written) producing academic works that consolidated many historiographical lessons learnt over the preceding years. This period continues to record the significance of the Civil War to historians in different academic fields.

The first period was marked by extensive autobiographical material that provided valuable insights into the leadership of both the North and South's military forces and governments. These works were additionally to provide the basis for subsequent debate and analysis on the wartime military strategies and tactics. Such studies were augmented by the writings of those participants in the war who held strongly partisan viewpoints on military operations and technology.

Remembering the massive impact a war of such proportions, length, and loss caused for this generation of Americans, the journals and general publications of the period mirror popular debate on the war. Periodicals such as Harpers, Century Magazine, Scientific American, United Service Magazine, North American Review and others (3) cover

3. Some others of note would be the Southern Historical Society Papers, Blackwood's Edinburgh Magazine, and the Journal of Royal United Service Institution. This is by no means an exhaustive list.

wartime events. In the 1880s, after a quarter century of reflection, these journals were responsible for re-evaluating the lessons of the war for the American public.(4)

In Britain the study of the Civil War was well served by both study from wartime observers, and later by historians drawing on Civil War lessons. Some of the most important observations were to be made in texts written by English officers; including Lieutenant Colonel J.A.L. Fremantle,(5) Lord Sir Garnet Wolseley,(6) Fitzgerald Ross,(7) Lieutenant Colonel Fletcher,(8) and the aging Duke of Cambridge.(9) This is not to discount many of the informative works written by European military observers of the war.(10)

In Britain the observations of military writers on the Civil War were to engender an outlook that was to survive the concentration of most European military writers on study of the Prussian military machine. To G.F.R. Henderson has been ascribed the accolade of confirming the war's importance as a study piece for British officers. His works also served to mark an important external assessment of the Civil War. His works offered both an impartial, clinical evaluation of the Civil War (based on primary sources), and propelled study on the international legacy of the war into the next century.

Henderson first wrote a treatise on The Campaigns of Fredericksburg (1891) which was intended for British officers to be 'instructed' on Civil War tactical lessons. His later works also included a biography on Stonewall Jackson (1898). However, his work on Stonewall Jackson, not only built on the earlier works 'instructional' emphasis but:

described each military situation as Jackson himself would have viewed it, and focussing his attention upon the methods and psychological reactions of his subject.(11)

4. Typical of these would be articles written by American generals like Meigs, Sherman, Rosecrans and others in Century Magazine in 1888. See the Battles & Leaders of the Civil War, (Reprint of Century Magazine War Series, 1888) (4 Vol.) (New Jersey, Castle, 1980)

5. Three Months in the Southern States April-June 1863 (London, Blackwoods, 1863)

6. Wolseley wrote extensively in the late 1880s and 1890s in RUSI, the United Service Magazine and North American Review & see Battles and Leaders of the Civil War (4 Vol.) (1888)

7. A Visit to the Cities and Camps of the Confederate States (London, Blackwoods, 1865)

8. History of the American War (London, 1865)

9. Duke of Cambridge, RUSI (Vol.9, 1866)

10. These would include the Russian Baron de Stoekl, The Comte De Paris, DeChanal, Prince de Joinville, the Prussian Major Von Borcke, and Major Justus Scheibert. See B.B. Sideman (ed), Europe Looks at the Civil War (New York, Onion Press, 1960:193, 237-239, & 285-288); & J.

Luvaas, The Military Legacy of the Civil War: The European Inheritance (Chicago, University of Chicago Press, 1959)

11. J. Luvaas, "G.F.R. Henderson & The American Civil War", Military Affairs (Vol.20[3], Fall 1956:144)

Writing in such a manner enabled the serious student of the war to evaluate not only tactics but the actions of Civil War battlefield leaders.(12) This approach engendered a strong tradition of similar biographies from American authors.(13)

From the turn of the century until the First World War there seems to be an increasing specialization of historical writings on the Civil War.(14) The completion of the Official Records on both land and naval warfare provided invaluable primary sources on the Northern and Southern military forces.(15) Writings on casualties, impact of certain technologies on warfare, and specific debates over tactics employed by generals began to stimulate concentrated analysis of the war.(16) Writers began to fully explore the economic, administrative, and social dimensions of the Civil War.(17)

Between the two great twentieth century wars the tradition of building on specific Civil War areas continued. The impact of the First World War influenced historians to look back on the nineteenth century to re-evaluate where and how such a destructive war had evolved. The American Civil War was examined for the indicators to future wars that the historians were then living through in the 1914 to 1946 period. This 'revisionist' school not only re-interpreted the war, but also promoted strong anti-war themes.(18) Many of these texts still produced novel insights into Civil War science and technology. New areas of specific research into science and technology were promoted by such works as Baxter's examination of ironclads,(19) Haydon's comprehensive study of aeronautics in the war,(20) Fuller and Steuart's identification of Southern small

12. Luvaas, The Military Legacy (1959:303-4)

13. Such as in the excellent text by P.A. Hutton, Phil Sheridan & His Army (Lincoln, University of Nebraska Press, 1985)

14. Ramsdell, "Changing Interpretation" (1937:3-27)

15. Official Records, "The War of the Rebellion, A Compilation of the Official Records of the Union & Confederate Armies" (70 Vol.-127 Books) (Washington D.C., Government Printing Office, 1880-1901); & Official Naval Records, "The Union & Confederate Navies in the War of the Rebellion" (31 Vol.- Including Index) (Washington D.C., Government Printing Office, 1894-1927)

16. T.L. Livermore, Numbers & Losses in the Civil War in America (Boston, 1901); W.P. Kremer, 100 Great Battles of the Rebellion (New Jersey, Hoboken, 1906); A.H. Burne, Lee, Grant & Sherman (London, Scribner, 1938); J.F.C. Fuller, The Generalship of Ulysses S. Grant (New York, Dodd-Murray, 1929); & D.S. Freeman, Lee's Lieutenants: A Study in Field Command (New York, 1944)

17. E.D. Fite's work on, Social & Industrial Conditions in the North During the Civil War (New York, Frederick Ungar, 1963, first published in 1909); Shannon, The Organization & Administration (first published in 1928), V.S. Clark, History of Manufactures in the United States (Vol.II) (Washington D.C., Carnegie, 1928), Lewis C Grey, History of Agriculture in Southern United States to 1860 (Washington, Carnegie, 1933)

18. Pressly, Americans Interpret Their Civil War (1954:295)

19. J.P. Baxter III, The Introduction of the Ironclad Warship (Cambridge, Harvard University Press, 1933)

20. F.S. Haydon, Aeronautics in the Union & Confederate Armies (Vol.I & II) (Baltimore, Doctoral Dissertation, 1941)

arms,(21) and the questioning of some traditional assumptions about Civil War science and technology.(22)

After the Second World War the studies began to reflect on the significance of the Civil War in the evolution to modern war. Once again writers, in common with their fellows 80 years before, were trying to comprehend the historical dimensions of a military conflict.(23) As themes such as economic factors, anti-slavery beliefs, nationalism, and human factors were introduced, different perspectives on the Civil War were promoted.(24)

As the individual approaches to the study of the Civil War began to narrow, texts began to address specific concerns. There were still general works solely intended for public digestion, but from 1961 to 1985 more scholarly attempts were also being made to amalgamate the broad approaches established at the turn of the century. Five core themes of historical interest seem to have been derived.

The study of strategy and tactics seems to have been the most popular area of debate on the Civil War. Writers have analysed battles at all levels of engagement and tried to improve understanding of why battles (and as such the war) progressed in the manner they did. Other authors have examined contemporary wartime writers on Civil War tactics (25) to construct an historical progression to modern times on how warfare has been conducted. Ancillary concerns encompassed armies manoeuvrability, improved communications (rail, telegraph, aerial signals, visual signals, etc.), better logistical support, rifled arms technology, trench warfare, and such like.

Autobiographical-leadership studies would form the next major approach consolidated since 1900. While closely aligned with studies of strategy, this approach has followed in the vein of writings begun by the original biographies of key Civil War leaders. Twentieth century writers have continued to pursue the link between understanding the people in the war, and the outcome of the war itself. Studies on political figures in

21. C.E. Fuller & R.D. Steuart, Firearms of the Confederacy (West Virginia, Standard, 1944)

22. Cohen, "Science & the Civil War" (1946); & P.D. Olejar, "Rockets in Early American Wars", Military Affairs (Vol.10, 1946:16-34)

23. See Luvaas, The Military Legacy (1959)

24. Pressly, Americans Interpret Their Civil War (1954:305-307); and excluding A. Nevins, The War for the Union (Vol.I & II) (New York, Charles Scribners, 1959) which introduced a more comprehensive analysis based on a number of themes.

25. Original works by Civil War contemporaries such as B.E. Upton, Infantry Tactics Double and Single Rank (New York, Greenwood Press, 1968 - Reprint of 1874); D.H. Mahan, A Summary of the Course of Permanent Fortifications & the Attack & Defence of Permanent Fortifications (Richmond, West & Johnston, 1863); & later modern analysis typified by E. Hagerman, "From Jomini to Denis Hart Mahan: The Evolution to Trench Warfare and the American Civil War", Civil War History (Vol.13, September 1967:197-220); & Jones, "Jomini & the Strategy of the America Civil War" (1970)

particular have been responsible for ascribing blame and promoting merit. As such works generated more research, definitive answers have become harder to agree upon.

The third approach that can be listed has caused even more controversial debate. Economic development is an heuristic approach that has evoked much contrary debate. Was the war a break with economic development and growth existing prior to 1861? Could the war actually have spurred industry and promoted economic growth? Or was the war to produce no significant contribution either one way or another?

Debate still continues over the interpretation of the often scant economic indicators of economic growth in the war. The methodologies used to interpret the data have actually become as important a point for debate as the final aim of assessing the war's impact on industrialization.(26)

Following closely upon the above approaches political issues have bridged many areas of controversy. Such approaches have considered issues from the consolidation of political parties, constitutional change, the reasons for Southern secession, the growth of federal government through wartime Acts,(27) the role of both warring states' Presidents and their administrations,(28) social issues,(29) and States Rights issues.(30)

The final approach that may be examined is the study of science and technology in the Civil War. In trying to understand the war through this approach writers have evolved a broad and indistinct field of study. Scholars have studied numerous military tools of the Civil War in great depth. Drawing on other records, militaria collections, relics, and contemporary studies, there exists a broad picture of wartime technical endeavour. Popular texts often follow the general approach developed by such comprehensive works as Coggins, Arms and Equipment of the Civil War (1960). Although around

26. Texts encompassing the arguments include R. Andreano (ed), The Economic Impact of the American Civil War (Cambridge, Schenkman, 1967); D.T. Gilchrist & W.D. Lewis, Economic Changes in the Civil War Era (Delaware, Eleutherian, 1965); O. Mayr & R.C. Post (eds), Yankee Enterprise: The Rise of the American System of Manufactures (Washington D.C., Smithsonian Institution Press, 1981); & H. Scheiber, "Economic Change in the Civil War Era: An Analysis of Recent Studies" Civil War History (Part II, 1965:396-411)

27. P. O'Brien, The Economic Effects of the American Civil War (London, MacMillan Education, 1988:58-62)

28. This area has excited great debate since 1865, see R.E. Beringer, H. Hattaway, A. Jones, & W.N. Still, Why the South Lost the Civil War (Athens, University of Georgia Press, 1986:426-429); D.D. Potter, "Jefferson Davis & the Political Factors in Confederate Defeat", in D. Donald (ed), Why the North Won the Civil War (Louisiana, Louisiana State University Press, 1960:91-112); & A. Nevins, Statesmanship of the Civil War (New York, Charles Scribners, 1953)

29. Emphasis on social factors often has fallen into political or economic texts, D.C. North, T.L. Anderson, & P.J. Hill, Growth & Welfare in the American Past: A New Economic History (New Jersey, Prentice Hall, 1983); & Fite, Social & Industrial Conditions (1963)

30. F.L. Owsley, States Rights in the Confederacy (Chicago, Chicago University Press, 1925)

1960 there were a spate of informative works that added to our understanding of specific military tools. These included studies by L Naisawald Grape and Canister: The Story of Field Artillery of the Army of the Potomac, 1861-1865 (1960), F W Hackley, Report on Civil War Explosive Ordnance (1960), G B Abdill, Civil War Railroads (1961), B R Lewis, Notes on Ammunition of the American Civil War (1959), and R McBride, Civil War Ironclads (1962).

Studies of Civil War scientific effort have tended to produce more general approaches. This is typified in works that include R V Bruce, Lincoln and the Tools of War (1973), A Hunter-Dupree, Science in the Federal Government: A History of Policies and Activities to 1940 (1957), N Rosenberg, The Economics of Technological Change (1971), C L Davis, Arming the Union: Small Arms in the Civil War (1973), and G H Daniels (ed), Nineteenth-Century American Science: A Reappraisal (1972).

Overall the most disappointing aspect of all the main themes studied has been the American sources inclination to 'internalize' the debate. One area of study has usually been emphasised above another, or the analysis has been directed to a 'popular', American based, readership. There is a significant lack of works with a predictive or universal framework that enable lessons from study of the Civil War to be applied in the study of subsequent wars.

The 'internalizing' of the Civil War debate is generally a reflection of international writers' failure to fully appreciate the importance of the Civil War. The separation between American and international military historians' approaches on the war can be traced back to the 1870s. While writers such as J F C Fuller,(31) Jay Luvaas,(32) Michael Howard,(33) and W McNeil (34) challenged others' disregard for Civil War studies, American authors failed to extend writings on the war into the contemporary world-wide academic debate. Intent on their own central themes writers all too often made few substantial efforts to bridge the gap between the American and the international perspective on the Civil War.

To the non-American student of military technology it is frustrating to have to study numerous works on the Civil War to gather relevant information and then, relate the American works to an international perspective on the war's importance to modern warfare. While some international texts now are beginning to carry out such studies,

31. J.F.C. Fuller, "The Place of the American Civil War in the Evolution of Warfare", Army Quarterly (Vol.26, 1933:316-325)

32. Luvaas, The Military Legacy (1959:303-4); & The Education of an Army: British Military Thought, 1815-1940 (Chicago, University of Chicago Press, 1970)

33. M. Howard, The Franco-Prussian War (London, Rupert-Davis, 1962); & The Theory and Practice of War (London, Cassell, 1965)

34. McNeill, The Pursuit of Power (1983)

for the most part general texts on modern warfare are loose historical studies of a number of conflicts; not all of which do justice to the importance of the Civil War.(35)

For those studying technology there is also an absence of studies placing military technical development into a wider context. Given the topic of this thesis, it is particularly dissatisfying to find so many works failing to emphasis technology as anything more than an identifiable physical entity. Perhaps it is difficult to study military technology whilst consideration is being given to other important themes, but such omissions have limited the context within which military technological change has been examined.

The single most important factor limiting the study of topics that cross a number of dominant approaches to a study of the Civil War (such as military technological change), has been the use of mono-causal explanations of the war. Unfortunately authors have tended in the past to stress one of the five major thematic approaches to the Civil War. Novel approaches to the study of the war are rare. Rather, attempts to broaden analysis to incorporate other themes, such as technology change, have been achieved through the reliance on secondary sources that have already promoted a parallel approach. An example of such a practice has been the approach to the study of Civil War generalship.

Debate on the relative merits of some Civil War generalship has encompassed biographical, autobiographical, original papers and despatches, strategic, and tactical studies. Despite so many works assembling authoritative sources and arguments, the field of study is still marked by the degree of dissent, rather than agreement. As the written work multiplies so do the different opinions and attitudes.

Attempts have been made to standardize the framework for analysing Civil War generals.(36) There was clearly a need for a predictive framework that could both assess the strategic and personal qualities of generalship, whilst still permitting comparisons with generals not in the Civil War. Subsequent studies have shown that the search for a more universal approach to the study of wartime military operations, and a means to assess the different qualities of the generals still continues.(37)

35. Some of the better examples of international writers re-evaluating the importance of the Civil War in a general history of warfare include E.M. Earle, Makers of Modern Strategy (Princeton, Princeton University Press, 1973); Glover, Warfare from Waterloo to Mons (1980); Chandler, The Atlas of Military Strategy (1980); & Parker, The Military Revolution (1988)

36. E.J. Stackpole, "Generalship in the Civil War", Military Affairs (Vol.24[2], Summer, 1960:57)

37. S.E. East, "Montgomery C. Meigs & the Quartermaster Department", Military Affairs (Vol.25[4], Winter 1961-62:183-196); T.H. Williams, "The Military Leadership of the North & South", in Donald, Why the North Won the Civil War (1960:33-54); Hagerman, The

The particular emphasis on General W T Sherman has been an indication of the attempts to make the study of leadership include elements such as military technology change. Studies on General Sherman have in particular examined the 'modern' nature of his leadership in the 1863–65 campaigns.(38) Some writers have also been keen to draw parallels between Sherman's approach to war that directly challenged the will and resources of the Southern people, and the 'total war' approach that has become evident in the twentieth century.(39) These studies on leadership have in such cases been used as an explanation for why the North won or the South lost the Civil War.(40)

Attempts to produce a common, more holistic approach to the study of the Civil War have extended beyond the study of generalship. This has particularly been evident in recent works such as R E Beringer, H Hattaway, A Jones, & W N Still, Why the South Lost the Civil War (1986), P O'Brien's, The Economic Effects of the American Civil War (1988), and E Hagerman's, The American Civil War and The Origins of Modern Warfare: Ideas, Organization, and Field Command (1988). From a historiographical point of view these titles represent important attempts to escape mono-causal explanations of the war.

Beringer (et al) have written with the deliberate intention of re-invigorating the approaches to analysis of the Civil War. They base their work on why the South lost the war and in so doing build upon earlier works in the area.(41)

Amongst their thought provoking conclusions were the findings that "overwhelming numbers and resources"(42) did not play a significant role in the outcome of the Civil War. They stress that explanation of the war in military terms could not satisfactorily resolve the debate over why the North won the war.(43) Beringer (et al) contends that studies of strategies and tactics are only important if it is recognized that the Union prevailed by conducting a strategy of attrition against a Confederacy that had an inability to mobilize political support for their cause.

American Civil War and the Origins of Modern Warfare (1988:xiii, 207–209); & Beringer (et al), Why the South Lost (1986:18–20)

38. E. Hagerman, "Field Transportation & Strategic Mobility in the Union Armies", Civil War History (Vol.34[2], June 1988:171); R. Wheeler, We Knew William Tecumesh Sherman (New York, Thomas Y Cromwell, 1977); B. Davis, Sherman's March (New York, Random House, 1980); & J.T. Glatthaar, The March to the Sea & Beyond (New York, New York University Press, 1985)

39. Beringer (et al), Why the South Lost (1986)

40. H. Hattaway & A. Jones, How the North Won: A Military History of the Civil War (Urbana, University of Illinois Press, 1983:ix); & Williams, "The Military Leadership of the North & South" (1960:45 & 53)

41. Williams, "The Military Leadership of the North & South" (1972:33–54); & Hattaway & Jones, How the North Won (1983)

42. Beringer (et al), Why the South Lost (1986:107)

43. E.M. Thomas, Book review of Why the South Lost, in The Journal of Southern History (Vol. 53[2], May 1987:336)

The authors also recognize the need for their study to address the issue of mono-causal explanations. They emphasise that:

Historians have assigned many causes for the South's defeat, some stressing a single cause, others many. But most assigned first place to one, even as they acknowledge the importance of others.(44)

However, Beringer and his fellow authors continue on to:

...single out the weakness of southern nationalism as what lawyers would call the proximate cause of confederate defeat.(45)

Mono-causal explanations are addressed, but more significantly they recognize that the broad context of any approach needs to be identified. Such recognition does not necessarily go onto incorporate all aspects affecting the central theme. Certainly technological change is not a major theme.

The essential lack of political will in the South is emphasised as the core theme explaining the Confederate states defeat. Despite efforts to do otherwise, the work becomes mono-causal in emphasis. In a review of the book E M Thomas also saw that the authors had narrowed their approach by the rejection of other arguments on economics, logistics, the make-up of southern society, and their resistance to the 'states-rights' thesis.(46)

In an attempt to place their study in the context of strategic analysis the authors use the pre-Civil War writings of Jomini and Clausewitz. This is intended to explain military operations through a set of "impartial judgements".(47) The precedent for using Jomini and Clausewitz in such a manner is not a unique development.(48) The authors believe, however, that the use of writers in tandem, rather than in conflict is able to provide a new insight into both the offensive and defensive operations of the North or the South.(49)

The need to explain outcomes and measure the modernity of the wartime strategy stems from the need to narrow the central theme to defensible grounds. By using Clausewitz the link between war and political considerations becomes nebulous. Clausewitz's concept of 'total' or 'absolute' war (involving the "breaking of the will of the people"), enabled the authors to confirm the nature the Northern war effort after 1863.

44. Beringer (et al), Why the South Lost (1986:3)

45. IBID

46. Thomas, Book review (1987:337)

47. Beringer (et al), Why the South Lost (1986:16)

48. Dates back to the wartime generals' writings, for a revival of the debate see E. Hagerman, "From Jomini to Denis Hart Mahan" (1967:197-220); & Hattaway & Jones, How the North Won (1983)

49. Beringer (et al), Why the South Lost (1986:17-18)

The reliance on the pre-war strategists' writings to interpret Civil War generalship has limitations. It is useful to refer to General Grant who stated:

If the Vicksburg campaign meant anything, in a military point of view, it was that there are no fixed laws of war which are not subject to the conditions of the country, the climate, and the habits of people. The laws of successful war in one generation would insure defeat in another.(50)

This should serve as a warning to any study of Civil War generalship. As Henderson's writings advocated, Civil War lessons offered instruction from history to guide his contemporary military peers. He advised that lessons had to reflect real life so as to avoid one of the greatest errors of war the "attempt to fight battles according to a scaled pattern." (51) To Henderson the study of Civil War generalship and any 'great captain' was necessary to stimulate thought rather than to yield set, scientific parameters for determining officer's actions.(52)

The question of why the North won is also only understood through coverage of why the South lost. In an earlier work Why the North Won in 1983, Hattaway and Jones had covered an eclectic range of issues from management of the war effort, support facilities, and general questions on the organization of military operations.(53) While the 1986 text is a more consolidated attempt to identify a single causal factor in the defeat of the South, there is great contrast in approaches.

Given the analysis in the 1983 work, there is no reason to suggest that the causes identified in the 1986 text can both account for the South's defeat, and explain why the North won. The 1983 text identified Northern advances in the organization of military operations, especially from 1863, as being significant reasons for the North's victory. However, the central thesis of the 1986 text states the Confederate States lost because they:

...succumbed to internal rather than external causes. An insufficient nationalism failed to survive the strains imposed by the lengthy hostilities.(54)

The emphasis denies not only other causal explanations but does not address the wider context of the study.

50. Quoted by U.S. Grant III in Donald, Why the North Won the Civil War (1960:5)

51. N. Malcolm (ed), The Science of War: A Collection of Essays & Lectures, 1891-1903: By the late Colonel G.F.R. Henderson (London, Longmans, 1910:71)

52. Luvaas, "G.F.R. Henderson", Military Affairs (Vol.20[3], Fall 1956:153); & J. Luvaas (ed), The Civil War: A Soldier's View (A Collection of Civil War Writings by Col. G.F.R. Henderson) (Chicago, University of Chicago Press, 1958:6)

53. Hattaway & Jones, How the North Won (1983:ix)

54. Beringer (et al), Why the South Lost (1986:439)

Earlier in their work Beringer and his fellow authors had attributed the demise of the Confederate armies to their morale collapse:

Victory...became the impossible dream because not enough confederates willed independence hard enough or long enough to win.(55)

Such a statement, taken with the main theme of the South's loss of the war, invites wider discussion. Patrick O'Brien in 1988 wrote that the South had not expected to wage a 'total war' and it was the loss of property (land, slaves, assets etc.) that proved a decisive cost blow to Southern attempts to wage war.(56)

Whether it was the South's desire to stop the war to preserve the remaining assets is debatable. O'Brien stresses the "grave" cost of the Southern attempt at secession.(57) To Beringer and his fellow authors such economic arguments confirm their central hypothesis. The southern will to wage war was implicitly being challenged.

Nevertheless, the study of the decline in the will of the South to wage war does not permit the direct role played by the North to be studied with equal emphasis. Why not state that the North won the war because after 1863 it was increasingly able to develop the military means to attack the property of the secessionists?

Beringer (et al) have provided a book that indicates how different themes may be synthesized through a single approach to explain why the South lost the Civil War. Obviously if interpretation of Civil War events is to be based around one theme, the approach may receive criticism. This criticism will most likely come from those who feel their areas of specific study are being made to fit a hypothesis, rather than being incorporated as part of a hypothesis which has a broad context capable of embracing important themes.

At the beginning of his work O'Brien identified three general hypotheses on the connections between the Civil War and the long-run progress of the American economy.(58) These explanations belied the extensive arguments and writings incorporated under the three simple headings. Yet they included: the belief that the Civil War hostilities interrupted rates of growth; the war produced no significant long-term impact on United States development; and, thirdly, the war removed barriers to development in some areas, so promoting more sustained rates of growth than could have been expected.

55. IBID:298; & the point was again made in Thomas, Book Review (1987:338)

56. O'Brien, Economic Effects (1988:17)

57. IBID:44

58. IBID:9-10

The very difficulties of identifying the impact of the war on economic or industrial growth has promoted uninformed debate and false assumptions. O'Brien believed problems arose because:

Imputation and measurement seem so intrinsically difficult to handle empirically that some historians prefer to make the reasonable assumption that in the absence of war economies would continue to grow at some specified pre-bellum rate of advance.(59)

O'Brien avoids false assumptions by examining previous approaches prior to making his findings. His economic approach builds judiciously on previous works and examines the political, industrial, and agricultural issues as part of his wider study of the economic effects of the war. The data on each issue is examined in part, then placed together to form a conclusion.

Nevertheless, O'Brien's work still presents an insight into other aspects of Civil War study. He for instance, presses into one small statement:

Furthermore, there seem to be few organizational or technical changes in industry which might be associated directly with the Civil War...In general, though, the war generated few innovations, even in weaponry, and served basically to distract scientists and technologists from the pursuit of more utilitarian objectives.(60)

While O'Brien is trying to concisely cover his central theme, a statement such as this represents an unsubstantiated broadening of his study. As such it invites criticism on grounds other than economics. While considering one approach O'Brien has at least recognized the need to strengthen his argument by considering other approaches and acknowledging their weaknesses.

One recent work that has attempted to break even further with the mono-causal approach to the explanation of Civil War military operations is Edward Hagerman's, The American Civil War and The Origins of Modern Warfare.(61)

Throughout extensive use of the Official Records, despatches and other primary resources Hagerman has produced a work that endeavours to provide an "organizational perspective".(62)

59. IBID:18

60. IBID:53

61. The American Civil War & The Origins of Modern Warfare: Ideas, Organizations, & Field Command (1988)

62. Hagerman, The American Civil War (1988:xvii)

The study conducted by Hagerman has fundamentally resisted mono-causal explanation. In his study he establishes two central approaches:

[1]...an attempt to break new ground in the analysis of theory, doctrine, and practice of field fortification in the tactical evolution of trench warfare.

[2]...a new analysis of the development of field transportation and supply to move and maneuver Civil War armies in the field.(63)

These central themes on land warfare are felt by Hagerman to best bring into synthesis developments in tactics and strategy around the dominant problems of mid-nineteenth-century field command.(64) Whilst synthesizing his study around field command he also draws together other issues such as strategic ideas and organization, and intellectual and institutional formation in the new mass industrial society.

Hagerman's canvass on the Civil War is very wide indeed. Yet his central theme is intended to pull together many areas of supporting study. His analysis of field logistics, and the use of wartime documents to establish the ratio of men to supply wagons and capacity of Civil War armies to support themselves by forage, built on works by earlier authors.(65)

Hagerman re-established (if such is possible) the importance of the war in the evolution of trench warfare when he linked the strategies of Jomini and the American strategist Denis Hart Mahan to the emergence of Civil War entrenchment.(66)

The study was conducted across a number of salient issues. As such the work relies upon the reader's specialized knowledge to provide the requisite knowledge linkages. Only then may the work be pulled together to form an integrated whole. Hagerman does not seem to provide one central theme that would direct all readers towards one specific conclusion. Without a conclusion to pull Hagerman's multiple factors together, his study does not synthesize the excellent detail into any framework whereby the Civil War's status as a modern war may be measured. The work certainly progresses logically through the study of Lee's Army of North Virginia, manoeuvre and tactics, the emergence of trench warfare, the evolution of the war of attrition, and the strategy, organization and manoeuvre associated with a war of exhaustion. Like Beringer, Hattaway, Jones and Still's earlier work, Hagerman is intent on illustrating the

63. IBID

64. IBID

65. C.W. Ramsdell, "General Robert E Lee's Horse Supply, 1862-1865", American Historical Review (Vol.35[4], July 1930:758-777); J.G. Moore, "Mobility & Strategy in the Civil War", Military Affairs (Vol. 24, 1960:71-72, & 69-74); & also see R. Goff, Confederate Supply (Durham, Duke University Press, 1969:240)

66. Hagerman, "From Jomini to Denis Hart Mahan" (1967)

importance of Civil War strategy to the evolution of trench warfare and 'modern' elements of warfare.

Without a strong central hypothesis the close scrutiny of areas in his work can reveal argumentative weaknesses. Hagerman stresses the growing use of field fortifications from 1861 to 1862. He attributes this to the increased use of rifled muskets during the first half of the war.(67) Yet such an explanation must be tempered by acknowledging that smooth-bore musket still dominated the Civil War battlefields in this period.(68)

The use of an order from General Sherman is used by Hagerman as an example of how the evolution of trench warfare progressed in the war.

...the skirmishers along our whole front will, during the night, advance within 100 yards of the enemy's works, and will, with spade or ax, prepare pits or fallen trees, so as to give them cover from which to kill artillerists who attempt to load the guns, also to keep down the fire of the enemy's infantry in the rifle-pits during the assault.(69)

Despite the attack failing and there being no indication of the success of the manoeuvre, Hagerman concluded that it, "was the most impressive appreciation of offensive entrenchment displayed to date..."(70) There is an extension in logic beyond evidence to suggest that because Sherman used offensive trenches once (without victory), that he would always adopt such tactics. As many studies are now indicating military leaders in the industrial era have not always consistently employed new battle tactics, even when new technology has irrevocably altered, or consolidated, certain tactics.(71)

So what do such isolated criticisms suggest for Hagerman's study? Most importantly, the attempts by Hagerman to undertake a study across a number of different themes has opened his conclusions to re-interpretation by those addressing specific issues. Yet his study is informative and able to shed new light on a number of *related* areas of military operations. The introduction of such a text into the Civil War library indicates the potential reward for those seeking to examine the relationship between strategic, organizational, logistics, and generalship in the war.

67. Although in fairness to Hagerman an earlier article was clearer in its linking of entrenchments and field fortifications to a tactical fall-back after initial battlefield manoeuvres and mass attacks were modified by local commanders during the first years of the war. See "From Jomini to Denis Hart Mahan" (1967:98-99)

68. Hess, Book Review (1990:358)

69. Quote in Hagerman, The American Civil War and the Origins of Modern Warfare (1988:203) from Official Records (Series I, Vol.XVI) (Part I, 1888:1090)

70. Hagerman, The American Civil War and the Origins of Modern Warfare (1988:203)

71. The Australian academic R. Pryor is about to publish an extremely interesting study on this very subject. He is co-authoring a study on General Rawlinson which examines his failure to consistently utilize advanced artillery techniques when attacking trenches in the First World War.

The reliance on mono-causal explanations of the Civil War is also challenged. For the historiography of the war Hagerman's text represents an attempt to utilize original source material upon the war, build on existing academic debates, and still produce original perspectives on the war's legacy to the modern era of warfare. Hagerman's approach reinforces the need for a strong central theme. If the study is to avoid criticism from those who specialize in the areas his broad approach trespasses across, then the hypothesis needs to offer a testable conclusion.

Hagerman offers both an inspiration and a warning to any study of military technological change in the Civil War. It indicates the need for a strong methodology that can bring together the different issues under examination. For instance, to produce a study of isolated technical entities that were developed in the war could not permit anything more than a mono-causal explanation of Civil War technological growth. It certainly could not address wider non-technical issues affecting innovation and invention. The exposition of the Civil War as a stepping stone to future modern wars ignores technical knowledge and overall innovative activity, for an emphasis on a supposed linear progression from the Gatling Gun or the ironclad to the machine-gun and dreadnought of the First World War.

Earl J Hess wrote an article "The Northern Response to the Ironclad: A Prospect for the Study of Military Technology" (72) in which he opened by stating:

The study of military technology is sizable and growing. The hardware of war machinery has fascinated scholars and generalists, but studies of responses to those new tools are relatively scarce.(73)

He continues on to outline a proposal for how Civil War technology may be studied in a wider context. Hess believed technology (in the case of the article the Northern ironclad), could be approached as a "response to military machinery that considered it as tools of prosecuting war"; and secondly as a "response that considered it as symbolic of technology".(74) These approaches accept technology as both a physical entity and as a representation of a wider process of technical growth in a social system.

These approaches represent an important attempt to escape the traditional study of Civil War technology as just physical entities. Ultimately Hess hoped a more comprehensive study could produce informative material that would be "no less important in the study of twentieth-century military technology." (75)

72. Civil War History (Vol.31[2], June 1985:126-143)

73. Hess, "Northern Response to the Ironclad" (1985:126)

74. IBID

75. IBID:142

Building on the works of Hess and Beringer (et al), O'Brien and Hagerman indicate the need for any study of military technological change to have a strong central hypothesis. This counters the problems with over reliance on a narrow, mono-causal study. Such an approach can also provide a framework by which to structure our insight into wars after the Civil War.

It is impossible to examine the whole process of technological change and then study one novel weapon in the hope it will reflect all technical changes. As unrealistic would be to thoroughly examine an isolated military technology whilst denying the influences wider technical innovations may have had on that design's evolution.

It is possible to extend Hess' own argument. Of what use it is to know what Northern ironclads were built in the war? We must also know if there was a substantial development in wartime shipbuilding knowledge, improved understanding of the design and evaluation of the final weapons, how the technology was utilized, the administration of the technology, and finally the legacy all these factors left for future ironclad development.(76)

A study of military technological change crosses geographic boundaries, political divisions, economic forces, strategic and tactical considerations, administrative and organizational factors, and ignores the distinctions made between naval and land warfare activities in the Civil War.

Ultimately, the evolution of technology is a continuous process. It has no one starting point or point of origin. Each design draws from different sources and has an incalculable impact on future technical development. Therefore, when technological development is studied as what Hess calls "a societal function" – or this thesis prefers to entitle as 'environmental function' – it is not just technical knowledge that must be studied but human action in the context of the Civil War.

1.2 Identification of Military Technological Change

To examine technology it is possible to follow two distinct approaches. These are analogous with an examination of scientific change where research is either conducted from an "internal approach" with the emphasis being on the substance of science as knowledge; or alternatively, an "externalist approach" where the analyst is concerned

76. For a contrast in naval technological development examine, for a pre-war situation, L.M. Pearson, "The Princeton & the Peacemaker", Technology & Culture (Vol.7, 1966:163–183); on the decay of the US Navy after 1865, S. Sandler, "A Navy in Decay", Military Affairs (Vol.35, 1971:138–141); & on the revival of the US steam navy in the 1880s, K.L. Moll, "A.T. Mahan, American Historian", Military Affairs (Vol.27, 1963:131–140)

with the activity of scientists as a social group within a larger culture.(77) Despite recent attempts to place the study of technological change to the broader context of its social environment,(78) there has remained difficulty in uniting the social scientists' approach with the natural scientists' concentration on technological change as an event derived from, and finally adding to, scientific knowledge.

A successful innovation reflects a whole range of development factors that have occurred in a wide social setting. These factors have largely been overlooked by natural scientists, with their concern more likely focussed on the end advancement made.(79)

To concentrate on the final successful invention as an addition to scientific knowledge, fails to recognize that technological change can occur with imperfect technical knowledge.(80) There exist lags between a new idea, its development, and its final adoption. As such it has often been the readiness of military leaders and bureaucrats to recognize technical potential, and quickly adopt a radical technology, that has played a very significant role in the successful development of new tools for war.

A study of non-technical factors may be the best indicator of how an innovation was able to affect military technological change.

Were we to look at the Civil War and solely examine technical factors we would ignore the important fact that technological innovation has no-one single, identifiable point of origin. This ultimately makes it foolish to draw final conclusions about the technical merit of any one technological entity, or make conclusions as to its contribution to scientific knowledge. For example the advantages of the Rodman type large calibre naval MLR cannon may be identified and its significant technical ideas examined. Yet, the design built upon preceding knowledge and work carried out by a number of innovators. Contemporary wartime belief still held that technical development of large calibre naval cannon had, with the Rodman, reached its ultimate point in scientific development. But this design was by no means to be the acme of cannon technology.

77. Kuhn, "The History of Science" (1968:76)

78. see L. White, Medieval Technology & Social Change (London, Oxford University Press, 1980); R.K. Merton, Science, Technology & Society in Seventeenth Century England (New Jersey, Humanities Press, 1978); Mayr & Post, Yankee Enterprise (1981); Fite, Social & Industrial Conditions (1963); H.J. Habakkuk, American & British Technology in the Nineteenth Century: A Search for Labour-saving Inventions (Cambridge, Cambridge University Press, 1962); & economic factors such as covered by Clark, History of Manufactures in the United States (Vol.II) (1928); & Andreano, The Economic Impact of the American Civil War (1967)

79. T.S. Kuhn, The Structure of Scientific Revolutions (International Encyclopedia of Unified Science Vol.2, No.2) (Chicago, Chicago University Press, Second edition, 1975:3)

80. Eg. the development of both the shell gun in the 1840s and later the BLR cannon were actually adopted prior to the US Navy overcoming production problems

The externalist approach also has developed some shortcomings in explaining technological change. The primary problem arises because from an extreme point the approach seeks to identify external forces that affect the intellect of the person carrying out 'scientific work'.⁽⁸¹⁾ Such an approach may be conducted on a general cultural level correlating scientific endeavour with cultural and intellectual histories.⁽⁸²⁾ From the perspective of technological change this general stance may overload the intrinsic factors impacting on how a technologist will conceive or interpret scientific knowledge that affects their technical work.⁽⁸³⁾

To explain the degree of Civil War military technological change the specific examination of some technical changes will counter-balance any study of the general environmental factors and barriers to technical growth. An invention must be judiciously examined as both an internal process with its own dynamic characteristics, and as a component of a wider process of discovery that impacts on a wider environment. Technology will, therefore, be studied as a function implicitly affected by its distinct environment.

1.3 Formulating a Methodology

Recognizing the limitations experienced by other studies on the Civil War, the foremost endeavour of this thesis will be to establish a framework within which military technological change may be identified and assessed. Given the complexity of the topic under analysis and the wide debate on methodologies of scientific explanation, it is not intended to simply produce a rational choice of a theory and reject all other theories preceding it.⁽⁸⁴⁾ Any number of theoretical constructs could give meaning to the data derived from the study of identified fields of innovative effort. But with regard to evaluating the process of scientific development this study is not about adding relative weight to the epistemological argument between Karl Popper, Thomas Kuhn, or any of the many philosophers on science.

Nor is this thesis advocating complete chaos in its approach to analysing military technological change in the Civil War. As has been seen with the examination of Hagerman's 1988 text on the Civil War, a framework is needed to order research, best explore the topic, reach some form of observation, and provide a guide-line for future

81. R. McLeod, "Changing Perspectives in the Social History of Science", in Spiegel-Rosing & De Solla Price, Science, Technology & Society (1977:151)

82. E. Lurie, "The History of Science in America: Development & New Directions" in G.H. Daniels (ed), Nineteenth-Century American Science: A Reappraisal (Evanston, Northwestern University Press, 1972:25)

83. P. Feyerabend, Against Method: Outline of an Anarchistic Theory of Knowledge (London, Verso, Seventh Impression 1987:211)

84. A.F. Chalmers, What is This Thing Called Science? (St. Lucia, Queensland University Press, 1982:135); & also Feyerabend, Against Method (1987:196)

students of the subject. Chalmers warns of the need for some methodological framework because:

Unless the descriptive account of science is shaped by some theory, no guideline is offered as to what activities and products of activities are to be described.(85)

While Feyerabend (86) encourages the production of new theories to make sense of the aspect of science they are examining, and so rid the academic world of hypothesis that seek to create uniformity, it may well be that no theory can avail this thesis better than one tailored to suit its purpose. As such this thesis is devoid of conscious alignment with any one of the methodological approaches espoused by modern theorists on scientific development.

Stretton is one scholar who has encouraged the social scientist:

...who emphasize the unlikeness, who design methods to take advantage of their subjects' unique capabilities to talk, intend, invent and introspect. These days there is plenty of support for this policy. But even its supporters desperately resist, still, one of its implications. For knowing causes, most social scientists whether they like it or not, rightly use the logic and methods which historians use. Both scientists and historians need to improve these methods, not replace them.(87)

As the basis of this work is to undertake a humanistic examination of the American Civil War's military technological change the study must now build upon the historiological perspective and seek objectively to identify military technological change. It can then measure its evolution beyond pre-existing science and technical knowledge, and finally, assess its growth to modern dimensions.

Reflecting back to the internalist and externalist debate and the above basis for this thesis, it is clearly necessary for any approach adopted to establish a means by which technological activity may be both identified and examined in the established historical context. The approach needs to be not only dynamic, but predictive.

(A) Technological Change During the Civil War

The first step in outlining an approach to this thesis is to define how the concept of technological change differs from scientific development. The debate between scholars over the relationship between science and technology has for many years now centred around the definition of science and technology, and the contribution of technical

85. Chalmers, What is This Thing Called Science? (1982:98)

86. Feyerabend, Against Method (1987:35 & 46)

87. H. Stretton, The Political Sciences: General Principles of Selection in Social Sciences & History (London, Routledge & Kegan Paul, 1972:197)

improvement to scientific development.(88) It is interesting to note that Gernot Bohme has identified four common approaches used to establish the relationship between technology and science:

- (a) science and technology develop autonomously and independently of one another;
- (b) science develops by orientating itself to existing technology and instruments (Eg. the emergence of thermodynamics on the basis of the technical development of the steam engine);
- (c) scientific as an instrument whereby, unlike the above approach, it is a decisive connector between science and technology, with the technology of science (measurement and experiment) at all times outrunning technology of everyday life; and
- (d) during the late nineteenth century there occurred a possibility of converting scientific knowledge into technology by grafting the craft technique of the previous centuries onto scientific development.(89)

Because the subject matter of this study falls most comfortably into category (d) of the common approaches, does not mean the other approaches will be ignored. Most of the distinction in establishing the different approaches revolve around the definitions of the key components. Between different exponents these vary greatly, therefore promoting great semantic confusion over what constitute science or technology activities.(90) As, for example, amongst the historian, philosopher, or natural scientist, the definitions of pure and applied science will differentiate their views on whether applied science actually is analogous to technology.(91) Activities specifically designated as innovation, invention, discovery, or development will vary to reflect the nature of the writers analysis.

Before proceeding any further with this study's approach to identifying technology change, definitions of the key terms are necessary to provide at least a guide-line to their future use.

88. G. Bohme, "Models for the Development of Science" in Spiegel-Rosing & De Solla Price, Science, Technology & Society (1977:337)

89. Bohme, "Models for the Development of Science" (1977:337-338)

90. N. Reingold, "American Indifference to Basic Research: A Reappraisal" in Daniel, Nineteenth-Century American Science (1972:45)

91. J. Agassi, "The Confusion Between Science & Technology in the Standard Philosophies of Science", Technology & Culture (Vol.7 [3], Summer 1966:364)

Technology

Technology has long been narrowly defined as just "...tools, techniques, procedures, things; the artifacts fashioned by modern industrial man to increase his powers of mind and body." (92) Such a definition recognizes that physical objects are derived from a combination of practical experience and existing empirical laws. (93)

As it ignores other human, non-physical characteristics of technology, such a definition is very narrow. Harvey Brooks has argued that:

... technology must be socio-technical rather than just technical, and a technology must include the managerial and social supporting systems necessary to apply it on a significant scale. (94)

During this study the broader humanistic definition of technology will be used to permit the additional consideration of the environment within which the technical objects are created, produced and exploited.

Science

The importance of technology as a distinct body of knowledge producing practical products and procedures can be explained only by understanding technology's relationship with science.

Science should be distinguished from technology as it evolves from theoretical laws derived from knowledge acquired in new or unknown areas of study. Science can also be considered as a distinct method that permits a body of knowledge to be formed, so providing a basis by which society may expand its beliefs and knowledge. (95) Fundamentally, technology's relationship with science arises because technical endeavour is responsible for manipulating and controlling the physical world after science's comprehension of its primary characteristics.

The relationship between technology and science became a symmetrical one after the Industrial and subsequent Scientific Revolutions of the nineteenth century permitted information and new knowledge to be transferred in either direction. (96) The

92. H.G. Rickover (Vice-Admiral), "A Humanist Technology", Nature (Vol.208 [5012], November 20, 1965:721)

93. C. Boyle, P. Wheale & B. Surgess, People, Science & Technology : A Guide to Advanced Industrial Society (London, Wheatsheaf Books, 1984:3; & J.K. Feibleman, "Pure Science, Applied Science, Technology: An Attempt at Definitions", Technology & Culture (Vol.2[4], Fall 1961:40)

94. H. Brooks, "Technology, Evolution & Purpose", Daedalus (Vol.109[1], Winter 1980:65)

95. C. Boyle, et al, People, Science & Technology (1984:2)

96. G.I. Rochlin (ed), Readings from Scientific American: Scientific Technology & Social Change (San Francisco, W.H. Freeman, 1974:2); & E. Layton "Mirror Image Twins: The

importance of science lay in its ability to act as a precursor to new technical activity indicating new uses for existing technical products.(97) Though science does not apparently set the limits of technological development, it is more likely to indicate possible solutions to those problems restricting technical endeavour.(98)

Pure And Applied Research

Since the nineteenth century scientific work has been divided into two schools: pure science and applied science. Pure science has to do with the 'need to know'. Applied research has been used predominantly by applied scientists to apply the lessons learnt in pure research to a practical human purpose.(99)

Applied research then becomes the transitional or linking point between science and a technological reality. Despite the often blurred links between applied research and technology change, during the Scientific Revolution pure research became an important means of producing insights and new knowledge about broader theoretical fields. This in turn produced the means for ushering in practical advances in technology.

Applied research from this period, however, increasingly became concentrated upon conducting practical experiments, or innovations based on 'known' technology. Thus applied research extended the uses and knowledge of established ideas or products.

Innovation

Technology innovation in this thesis will be defined as the "process that begins with an inventor's insight and ends with a new product or technique" being created.(100) Innovation is not just the practical improvement of hardware. It is also the reshaping of concepts or ideas. The innovation process forms the basis for individuals to inject pure research, applied research, scientific knowledge and technical "know-how".

Innovation is not held within this thesis to be the same as discovery or invention where a new technical entity unlike any known previous technology, is produced. Discovery is the production of new technical or scientific knowledge. This is distinct from invention which is usually the result of pure research discovery, or the unique combination of

Communities of Science & Technology" in Daniels, Nineteenth-Century American Science (1972:228)

97. J. Ellul, The Technological Society (New York, Alfred A. Knopf, 1976:9-10)

98. A. Zvorikine, "The History of Technology as a Science & As a Branch of Learning: A Soviet View", Technology & Culture (Vol.2[1], Winter 1961:1)

99. Feibleman, "Pure Science, Applied Science, Technology" (1961:305)

100. S.B. Lundstedt & E.W. Colglazier (eds), Managing Innovation: The Social Dimension of Creativity, Invention & Technology (New York, Pergamon Press, 1982:xiii)

established knowledge, to produce a novel technical entity. Innovation is the improvement to identified technology, ideas or techniques.

Technology Change, Growth, or Development

The completed innovation produces a complex source of change that does not stop with the alteration of an existing technical entity. It may also a conceptual basis for addressing problems that have afflicted society. Thus the wider technological environment – social, political, economic or organisational factors – may be influenced by technology change and in turn produce secondary effects that are far from apparent immediately after the original innovation's introduction.(101)

The impact of technology change may therefore be spread over an extended period of time with only minor incremental improvements to existing technology.(102) The impact and course of technology change may also be complicated by technical drift of the introduction of innovations from other countries.(103)

The incremental change to technology can be overtaken on occasions by radical or dynamic 'breakthroughs' in technology that quickly alter existing products or processes and may swiftly alter existing environmental conditions within which future technological innovation occurs.(104) The more radical a 'breakthrough', the wider is the base for new or novel innovative effort to accelerate technology change.(105)

Because significant discoveries and technological change cannot be ordered or pre-ordained, the innovation that changes technology may be derived only long after the original 'breakthrough'.(106) Hence great periods of innovation can then be followed by stagnation. Basically, if conceptual breakthroughs do not occur or cross-fertilisation of practical development areas is not encouraged, the full potential of technology change may not be realised and its actual impact limited. The impact of a final innovation is also affected by the fact that in the mid- to late-nineteenth century the development in fields of technical endeavour progressed at varying speeds. This meant that technologies were often exploited depending on how they contributed to existing areas of technical growth rather than where they originally were intended to be applied.

101. M. Kranzberg, "Technology & History: 'Kranzberg's Laws'", Technology & Culture (Vol.27[3], July 1986:545)

102. Lundstedt & Colglazier, Managing Innovation (1982:xxiii fn)

103. H.G. Gelber, "Technical Innovation & Arms Control", World Politics (Vol.26[4], July 1974:510)

104. T.P. Hughes, "Conservative & Radical Technologies", in Lundstedt & Colglazier, Managing Innovation (1982:32); & R. Landau, "The Innovation Milieu", in IBID:54

105. Landau, "The Innovation Milieu" (1982:54)

106. S. Zuckerman, Scientists & War: The Impact of Science on Military & Civil Affairs (London, Scientific Book Club, 1966:128–129)

In the military arena technological change has focussed on the provision of those technical tools and the techniques by which warfare may be waged. But military technology was significantly affected by the technical developments occurring outside just its own field of endeavour. It may be argued that from the Industrial Revolution until the Second World War military technology satisfied its scientific and technical knowledge demands from the same source as commercial manufacturing demands.(107) This meant that military technology was also being changed by innovations occurring within the general environment.

(B) Means to Measure Technological Change in the Civil War

The study of military technological change needs to move beyond a concentration on individual weapon innovations and the resulting changes to military doctrine. This broadening of the study does, however, raise problems over how one may measure the wider concept of technological change. Edwin Layton in "Conditions of Technological Development" (108) lists the six most common means by which the measurement of the growth in technology and technique occur.(109) Although mainly based around contemporary analysis, (acknowledging that the best data are probably the statistical compilations by advanced governments and international agencies on the deployment of personnel and money in science and technology) Layton's categories may still be useful if they can explain technological development in a historical context.

Layton's six approaches include:

- (i) production functions
- (ii) patent statistics
- (iii) indirect social costs and benefits
of technological change
- (iv) the study of innovations
- (v) the flow of information
- (vi) embodiment of science in technology

The examination conducted by Layton was not conducted with specific reference to an historical examination of technological change. However, from an historical perspective his approaches may increase our understanding of Civil War military technological changes.

The search for statistics and material on production functions, and the social cost or benefits of technological change, could be rejected because it would require much work for uncertain gains. General data on the rate and direction of economic change may be

107. IBID:28

108. E. Layton, "Conditions of Technological Development", Chapter 6 in Spiegel-Rosing & De Solla Price, *Science, Technology & Society* (1977:197-221)

109. IBID:199-204

detailed,(110) but precise contemporary figures on social costs such as labour unemployment, pollution, social dislocation, and such forth, would be difficult to identify. To identify all growth not directly attributed to capital and labour inputs, will ultimately only produce an aggregate production function that is "a rather crude index of technical growth".(111) Neither the first or the third approaches identified by Layton could establish the extent to which technical changes affected individuals or impacted on specific scientific knowledge.

Patent statistics do offer a more useful tool to indicate technical activity on individual innovation types,(112) and illustrate design fluctuations.(113) Patent statistics, however, do not indicate the level of innovation; only claims to property. In nineteenth century America, patent figures are exposed to uncertainty due to institutional and political changes. They, therefore, could be usefully employed to provide an indication of short-term indexes to work on single types of innovation.(114)

The flow of information and the embodiment of science in technology both rely on extensive analysis of technological knowledge through the study of contemporary journals and scientific literature. Changes to the scientific community and the core discoveries that promote further research, may be mapped through establishing "explicit linkages between papers that have particular points in common."(115) These links become apparent through the tracing of footnotes acknowledging preceding work. As an historical research tool into the growth of science and technology, Derek de Solla Price has produced a number of works that statistically link the amount of published scientific material with increased technological activity.(116)

Both approaches are interested in simplifying the chronological collation of available material on specific science and technology subject matter.(117) They are not specifically interested in providing a method that can delineate individual technological

110. North (et al), Growth & Welfare in the American Past (1983); & S.L. Engerman, "The Economic Impact of the Civil War", Explorations in Entrepreneurial History (Vol.3[3], Spring 1966:176-199)

111. Layton "Mirror Image Twins" (1977:200)

112. R. Rothwell & W. Zegveld, Industrial Innovation & Public Policy: Preparing for the 1980s & the 1990s (London, Francis Pinter, 1982:118)

113. J Schmookler, Invention & Economic Growth (Massachusetts, Harvard University Press, 1966) in Layton, "Mirror Image Twins" (1977:200)

114. see V.D. Stockbridge, Digest of Patents Relating to Breech-loading & Magazine Small Arms (Except Revolvers). Granted in the United States from 1836-1873, Inclusive (Washington DC, U.S. Patents Office, 1874)

115. E Garfield, Citation Indexing - Its Theory & Application in Science, Technology, & Humanities (New York, John Wiley & Sons, 1979:90)

116. D.D. Price, "Is Technology Historically Independent of Science? A Study in Statistical Historiography" Technology & Culture (Vol.1, 1966:553-568)

117. Garfield, Citation Indexing (1979:89-90)

changes. The method is heavily reliant on scientific and technical journals and papers providing coverage of important advances in scientific knowledge when they occurred.

It is the study of innovations that may prove Layton's most useful category for analysing Civil War technological change.

The study of innovations can give an insight not only into individual innovative effort, or innovation events, but give wider implications as to why innovators failed.(118) The level of study identified also may be cross-national or specific to time, region or field of endeavour. Using his approach Layton presents innovations as nebulous items without uniformity of purpose, atomistic unity, or clear sets of stages.(119) Innovations may even be sets of different innovations that when aggregated produce a single end technical advancement.(120) He, therefore, proposes that there exists the need for a model to make sense of the separate innovative efforts.

It is evident that a study of innovation can provide the best means by which this thesis can assess the separate additions to technical knowledge. Such an approach will additionally permit an examination of technological entities from a human perspective. Ultimately, it will be possible to gain an insight into whether technical knowledge progressed beyond the pre-1861 era of warfare.

The study of innovations may be usefully broadened by the inclusion of material relating to patent records, and social factors that impacted on Civil War military technical development.

Through the study of each innovation this thesis would in no way become dependent on general observations of military technological change. Innovations can be analysed separately, with each observation not acting as a guide to the choice of future innovations studied, or necessarily determining what course of evolution all following innovations would take.(121) Simply, innovations are not isolated events. They may be the result of other technology changes, or themselves generate technology change. There does not necessarily exist clearly identifiable links between the studied technology, the modifications, or the cumulative alterations that altered the preceding technical knowledge.

118. Layton "Mirror Image Twins" (1977:202); & On the Shelf: A Survey of Industrial R & D Projects Abandoned For Non-Technical Reasons (London, London Centre for the Study of Industrial Innovation, July 1971)

119. Layton "Mirror Image Twins" (1977:202-203)

120. IBID:203

121. J. Agassi, Science in Flux (Boston Studies in the Philosophies of Science, Vol. 28) (Boston, Reidel, 1975:85)

The analysis of certain innovations permit a flexible means for assessing changes to specific fields of military technical endeavour, at given points in time. Nevertheless, it is necessary to have some form of general model. This should enable this thesis to construct general conclusions that can make sense of insights gained from the study of separate innovations.

(C) The Innovation Process and Sources of Technical Development

After his analysis of the means to measure technological growth Layton goes on to examine the Linear-Sequential Model as a means to diagrammatically explain technical development through a study of its sources. The model when applied assumes:

...that the events leading to innovation can be arranged in a linear sequence of cause and effect and that the first events cause or account for the remainder. These models fall into two broad categories: 'discovery-push' and 'demand-pull'. Linear sequential models of the inventive and innovative process in effect define the structure and functioning of a technological system. In this connection, it should be noted that these models are all based on *a priori* assumptions, rather than on investigation of how knowledge, in fact, really does work.(122)

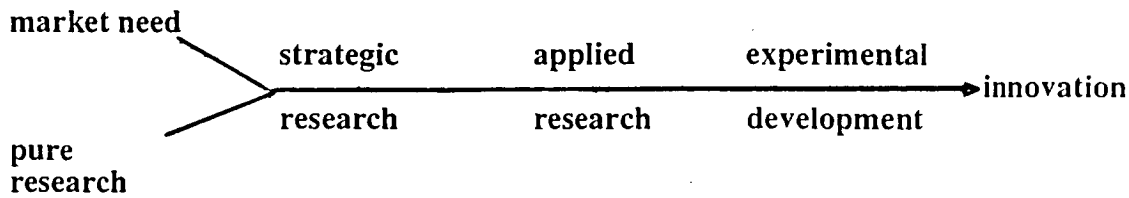
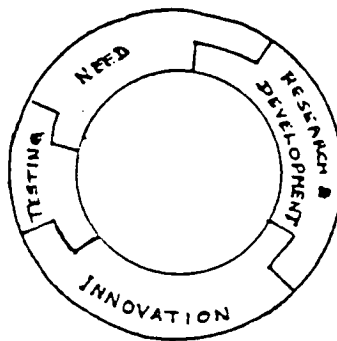
The Linear Model holds additional value when used to assist in the historical examination of technological growth. The Linear Model encourages the examination of gaps between different sequential stages such as discovery, development and actual application. This emphasis also produces some of the major faults identified with the model. The phases concentrate on interpreting the sequential progress of a given innovation's development. They do not identify how scientific knowledge may influence different stages of the innovation process.(123) The 'need-pull' and 'discovery-push' emphasis of the model attempts only to provide some social and scientific reasons for the spur to innovate.

The Linear Model may, however, still be utilized to study the innovation process within a given time-frame and produce a simplified means by which to order the data on overall innovative activity.

To avoid the specific time-frame and sequential nature of the Linear-Sequential study of innovation, a Cyclic-Continuum Model may be used as an alternative means to explain innovation. Unlike the Linear Model, the Cyclic Model groups the general tasks of innovation into distinct phases. These phases have a sequential relationship but no logical beginning or finishing point.

122. Layton "Mirror Image Twins" (1977:204-205)

123. IBID:205; & J. Ronayne, Science in Government (Victoria: Australia, Edward Arnold, 1984:65)

Figure 1 Linear Model (124)**Figure 2 Cyclic Model (125)**

The Cyclic Model depicted emphasises the interrelated nature of the innovation process, but denies the existence of any sequential phase of progression. It does establish that need or demand will provide the dominant motivation for undertaking changes to existing technology.(126) The acceptance that demand stimulation may initiate an innovative activity does not necessarily mean that the innovation process will always commence from that point. Within a cyclic process the innovation process may start from any point, without necessarily progressing sequential through all phases.

By way of contrast the Linear Model does emphasise that need and pure research discoveries will jointly form the most likely starting point for a sequential process that will end with an innovation. This appreciates that market demands may initiate a new dimension to investigations, while new market demands may be created by breakthroughs in pure research.

Pure research is only acknowledged by the Cyclic Model in its research and development (R & D) phase. Here it is coupled with the investigation of specific issues, knowledge, data or products that will satisfy applied research goals. This phase is

124. Ronayne, Science in Government (1984:44)

125. G.H. Daniels, "The Big Questions in the History in American Technology", Symposium: The Historiograph of American Technology, Technology & Culture (Vol.11[1], January 1970:8)

126. Schmookler, Invention & Economic Growth quoted in Daniels, "The Big Questions in the History in American Technology" (1970:7)

further broadened with the development of research that will encompass a field of technical knowledge. Through pure and applied research and development, technology is developed to ultimately produce a novel innovation.

The Linear Model refers to the second phase of the innovation process as strategic research. This is carried out with the expectation that it will provide a broad base of knowledge that can form the background for delineating the parameters of study necessary to devise a specific innovation.(127) The Linear Model follows the strategic research phase with separate phases of applied or practical research aimed at specific investigation of the problem at hand. It is in the fourth phase of experimental development that efforts are made to systematically draw upon research work that can produce a distinct new product or process.(128) Only then is the innovation made and utilised.

Unlike the Linear Model, the Cyclic Model regards innovation as a stage occurring after research and development. The innovation stage also does not mark the end of the innovation process, but paves the way for continued development effort. For the Cyclic innovation process a testing phase follows on from the creation of an innovation. This recognizes not only the refinement innovations undergo before or during initial use, but also that the experimental phase may instigate new courses of innovation away from that originally intended. This in turn may start the innovation process all over again.

Overall, the Linear Model is more intent on explaining the development of an individual innovation. This development is studied through separate and sequential phases of progression. In contrast, the Cyclic Model prefers to depict innovative endeavour as evolving through broad phases, without an actual beginning or end. As Peter Drucker stated, the impact of technology tends to be:

...synergic and the result of several developments, each independent in its origins and the outgrowth of a separate discipline with its own "experts"...Further, the impact of technology are often quite indirect, and by-products rather than main products.(129)

Despite these differences in emphasis, both models may be placed in a surrounding environment which influences the progression of an innovation.

127. Ronayne, Science in Government (1984:35)

128. IBID

129. P.F. Drucker, "Comments: Is Technology Predictable?", Symposium: The Role of Technology in Society, Technology & Culture (Vol.10, No.4, October 1969:524)

The Linear Model's specific intention is to be a diagrammatical representation of the complex innovation process, that in delimiting its phases, must incorporate the variable influences of science and government into the development of a final innovation.(130) The Cyclic Model is more general. Whilst establishing the general phases of an innovation process, it does not see the interaction between these phases – or the overall cyclic process – as being a separate function of any greater social system. Rather, all environmental influences, whether positive or negative, are inherently important in shaping the progress of innovative activity.

Both models basically recognize that the innovation process is made up of a number of phases that collectively end with the production of a new technological entity or idea. Additionally, while the process in reality rarely progresses through a logical continuum, both models are intent on identifying the distinct phases that may map the progress of innovative activity.(131)

Ultimately, then, insight into the general conduct of innovative effort in the Civil War can be achieved by contrasting either the Linear or Cyclic model's insight into the nature of the innovation process. Of especial interest will be if the models of the innovation process can cast light onto the highly pertinent question as to whether Civil War military technological change can be understood by examining whether pure research changes to established technical and scientific laws ('discovery-push') pre-empted technological changes, or combat needs promoted demands ('demand-pull') for the establishment of improved military technology or techniques.

1.4 Propositions

It is proposed that the non-technical barriers affecting the development of certain innovations may yield further information than a concentration just on an examination of technical changes. The approach adopted by this thesis to the study of innovation may, therefore, be guided by some important propositions.

- (1) From a study of key military innovations we may better understand the evolution in technical knowledge in the Civil War, over that which preceded it.

130. Ronayne, *Science in Government* (1984: 44)

131. Gelber, "Technical Innovation & Arms Control" (1974:510)

- (2) Derived from an examination of the general innovative environment it is possible to identify non-technical factors important to the development of new technologies. Further, it may be possible to establish the role non-technical factors played in influencing the nature and development of those key innovations identified.
- (3) If the previous propositions can be established then, ultimately, an assessment may be made of the Civil War innovative effort, and the war's impact on future developments in military strategy and technology.

This thesis will aim to *determine not only how innovation confirmed, developed, or amended established technical knowledge; but also how environmental factors affected wartime technological change.*

1.5 Structure and Content

Given the propositions, this thesis is subsequently divided into three major sections. The first part deals with technical change, the second with environmental factors, while the final part covers the impact of Civil War technological change.

The whole structure is designed to build upon Part I where there occurs an identification and examination of the key military technological changes of the Civil War. Having carried out this study it is then possible in Part II to examine the role surrounding environmental factors played in promoting these innovations to their full military potential. This study may then finally lead to Part III, where an assessment is made of the overall impact of Civil War innovations.

The three chapters of Part I deal entirely with the innovative activity present from 1861 to 1865. The theme of these chapters is to test the first proposition through an examination of specific technological changes. Of additional assistance will be the ability to highlight if technical innovations provided a co-operative impact on the incremental development of other innovations. Essentially this will permit an examination of how these innovation's consolidated previous technical knowledge. Thus the nature of key innovations on land, at sea, and in related areas will reveal the character of technological endeavours in the war.

Part II will deal with environmental factors. This will challenge the second proposition that it is possible to identify non-technical factors that were important to the development of new technical entities.

o answer the extent to which innovations were rationally promoted, chapter 5 will examine the role of government, industry, and society. It will examine their impact on efforts to produce, co-ordinate, test, and utilize the innovations identified in Part I.

Chapter 6 will examine how at the end of the war the pool of "acceptable" military technology and knowledge derived from practical research, had been administered by the relevant, formal, Northern military organizations. This examination will show how, despite reforming to nurture new military technical entities, the organization's capacity to accept new technology lagged behind the pace of innovation, and affected the development of certain technologies.

In concluding Part II, chapter 7 will apply the lessons derived in the two previous chapters to see how specific non-technical factors impacted on key technological changes.

The third part of this thesis addresses the final proposition. It should provide a balanced assessment of the often complicated course of Civil War military technological change based on the preceding chapters' discussions. It will endeavour to measure the impact of the identified technological changes, and assess how much these non-technical limits actually affected the ultimate technological legacy of the war.

Drawing from previous parts, chapter 8 can go some way to test the overall impact technical military innovation made during the Civil War. This study will then be extended in Chapter 9 to examine the impact changes to Civil War arms and strategy made on the international arena. Together, these two chapters will be able to highlight how the changes to military technology produced arms and strategic developments that were to alter the way wars were conducted.

Faced with the difficulty of carrying out a consolidated study of the overall process of Civil War innovative effort, chapter 10 intends to provide a theoretical construct. It will establish how far the war can be said to conform and act in relation to models of the modern innovation process. This will permit each stage of the Civil War innovation process to be assessed, while also making it possible to gain an impression of the contemporary innovation processes' modernity. This final stage in Part III's study on the impact of technological change will round off the study by referring to the modern dimensions of the war's innovation process.

It needs to be re-emphasised that all models of the innovation process are simplifications of the complex process of innovative change. Based on assumptions that order complex interactions, they add understanding through the use of diagrammatic

symbols.(132) The model of the Civil War innovation process will only be derived from study conducted in the thesis, it is not a summary of the work's findings, nor will it be a scientific theory derived inductively from the observations made here.

132. A. Kaplan, The Conduct of Inquiry: Methodology for Behavioral Science (California, Chandler, 1964:280)

PART I

TECHNICAL CHANGE

PART I

TECHNICAL CHANGE

INTRODUCTION

The importance of the specific technical changes in the Civil War must be established before military technological change and the volume of overall innovative effort may be assessed.

Extensive technical innovation produced many novel land warfare arms. In transportation, the railroads were elevated to a pre-eminent position in logistics and so re-shaped military strategy. New dimensions to warfare were also consolidated by the deployment of electric telegraph systems and the use of balloons.

At sea the advances in naval technology were embodied in combat between steam-driven ironclad warships, and by the deployment of torpedoes in defended waters and their use as offensive weapons on torpedo boats and submarines. In addition to the plethora of innovations dealing specifically with naval or land warfare, there existed a large but less specific body of endeavour, in areas such as ordnance and artillery. Developments in these areas made broad contributions to technological change.

The importance of wartime military innovations to the promotion of technical knowledge has been much debated. For example I B Cohen wrote in an article in 1946 that the first:

large scale organisation of technical and scientific resources of man power during the Civil War marks that conflict as the transition point in the technology of warfare.(1)

However he, like writers who followed, failed to stress the complications arising from using a study of key innovations, to show how the Civil War was more technically advanced than previous periods in history.

As isolated acts, changes to military technology are very difficult to examine. Technology change is more of a cumulative process, where development results from shifts in how science and technology unite to advance society's existing technical knowledge.(2) Technology is, under such circumstances, not just a practical tool or technique, but can be responsible for improving manufacturing ability, or as an endeavour undertaken to fill specific needs. This contribution may be radical and

1. I.B. Cohen, "Science & the Civil War", Technology Review (Vol.48, 1946:167)

2. Brooks in S.B. Lundstedt & E.W. Colglazier (eds), Managing Innovation (New York, Pergamon Press, 1982:12-13)

produce immediate, dynamic change.(3) However, most technological development tends to be conservative and involves long-term improvement to existing technology.(4)

It is clear that there exists what some authors call an incubation period (5) or a period of technology lag.(6) These terms portray technological change as a process that is not embodied in a technical design occurring at any one moment in history. It may occur "so slowly that decades pass before the historical record reveals much change."(7) Society may experience a lag between the time technology changes and the time when institutions, attitudes, or other active forces in society realise the full benefit of that technology.(8)

Having established that the act of technological change may not have an immediate impact on a society, one should not then expect all innovations to immediately generate technical change. It is axiomatic, that technological knowledge utilized in the Civil War may have originated before 1861 and continued to influenced future technological change after 1865.(9)

Thus, while Part I will deal with an examination of Civil War technological change through an identification of specific innovations, the detail derived from this analysis will make possible a later assessment of the influence of other non-technical factors that impacted on the introduction of key technical entities.

3. T.P. Hughes, "Conservative & Radical Technologies", in Lundstedt & Colglazier, Managing Innovation (1982:32)

4. IBID:32; & R. Landau, "The Innovative Milieu", in Lundstedt & Colglazier, Managing Innovation (1982:54)

5. R.K. Merton, Science, Technology & Society in Seventeenth Century England (New Jersey, Humanities Press, 1978:42); & J.K. Feibleman, "Pure Science, Applied Science, Technology: An Attempt at Definitions", Technology & Culture (Vol.2[4], Fall 1961:313)

6. Lundstedt & Colglazier, Managing Innovation (1982:Footnote, xxi); & N. Rosenberg, Technology and American Economic Growth (New York, Harper Torchbooks, 1972:17)

7. S. Zuckerman, Scientists & War (London, Scientific Book Club, 1966:127-128)

8. G.H. Daniels, "The Big Questions in the History in American Technology", Technology & Culture (Vol.11[1], January 1970:2-3)

9. H. Rose & S. Rose, Science & Society (London, Pelican Books, 1970:240 & 245)

CHAPTER 2: TECHNICAL CHANGE TO MILITARY WEAPONS

In a war dominated by the importance of infantry engagements, technical developments of infantry weapons played a significant role.⁽¹⁰⁾ By surveying technical innovations in land warfare, it will be possible to evaluate the progress of different weapons technology. This assessment will centre on the study of innovations in breech-loading and magazine-fed small arms, breech-loading cartridge ammunition, railroads, balloon warfare, and the field telegraph. Together these areas have stood as major advances in technical knowledge and represent a new level in the industrialisation of warfare.⁽¹¹⁾ Reviewing these technical innovations, individually and collectively, will make it possible later to assess their impact on overall changes to military technology.

2.1 Breech-loading and Repeating Small Arms

Prior to the Civil War, the United States had a history of experimentation in small arms design. Many American inventors had in particular become interested in producing an effective breech-loading shoulder-fired weapon. Most famous of these early breech-loaders was John H Hall's, which was granted a patent as early as 21 May 1811, for its breech-loading action.⁽¹²⁾ The ubiquitous rifle was the American breech-loading carbine, which, from 1819 until the Civil War, went through many design modifications and itself became the basis of so many other weapon prototypes.

Immediately prior to the Civil War and during its early months, the foundations for further wartime development in breech-loading weapons were made by important weapon designs, such as the Burnside, Starr, Gibbs, Gallagher, Maynard and Sharp's percussion breech-loading carbines.⁽¹³⁾

Although based on earlier designs, wartime carbines incorporated many important innovations. Technically, the most important advancement in breech-loaders was the greater operational efficiency of those weapons manufactured towards the end of the war. Improvements sought to rectify poor breech assemblies that separated and released gas when the expelled gases from fired bullets pressured imprecisely manufactured breech-blocks and chambers,⁽¹⁴⁾ poor trigger mechanisms, under

10. F.A. Shannon, The Organization & Administration of the Union Army (Vol.1) (Massachusetts, Peter Smith, 1965:107)

11. C. Boyle, P. Wheale & B. Surgess, People, Science & Technology (London, Wheatsheaf Books, 1984:154)

12. D.F. Butler, United States Firearms: The First Century, 1776-1875 (New York, Winchester Press, 1971:132)

13. Butler, United States Firearms (1971: Chapter 5 & 6); & National Rifle Association of America, Civil War Small Arms, An American Rifleman Reprint (Washington, NRAA, 1960:16-21)

14. C.L. Davis, Arming The Union (Port Washington, Kennikat Press, 1973:120-121)

powered hammer spring catches that failed to ignite percussion caps, inefficient means of extracting rounds, and overly complex manufacturing that hindered the design.

By the later stages of the Civil War it was possible to see a marked advance in the arms and equipment issued to the Union armies.⁽¹⁵⁾ By 1865 design refinements had produced such weapons as the improved 1863 Sharps wartime model and the Remington split-breech, Ballard, Sharps and Hawkins, Joslyn, Warner and Palmer single-shot cartridge carbines.

However, this is not meant to suggest that each was an ideal design. Rather, each design represented a progression towards a more complete breech-loading small arms system. The Ballard for instance, was a competent design, with an excellent sliding cartridge extraction stud under the forestock.⁽¹⁶⁾ Most designs used improved ammunition with some form of fulminate incorporated in the cartridges, in particular the Remington split-breech design had an advanced hammer-firing pin design to ensure reliable strikes on cartridges. The Palmer Carbine, although adopted too late to be used widely in the war, was the first bolt-action, metallic cartridge shoulder arm used by the United States armed forces.⁽¹⁷⁾

Despite the concentration of inventors on breech-loaders and the exciting experiments with many ingenious designs, very poor weapons were possibly more prevalent than good ones. This is manifest in the wasted effort and revenue spent on bad designs, whilst it seems superior weapon designs had no advantage in the competition for official endorsement.

On balance, despite the abundance of many inferior production weapons, the success of the Sharps lever-action single-shot carbine and the venture into hybrid repeating breech-loading weapons, stand as testament of the efforts to improve existing weapons technology.

These improvements may be followed through a variety of related technical designs.

The most important breech-loading repeating rifles of the Civil War (besides the less ingeniously designed five-shot, revolving cylinder Colt percussion carbine) were the Spencer, Henry and Ball weapons.⁽¹⁸⁾ Unlike the incremental growth in technical knowledge associated with single-shot breech-loaders, repeating rifles underwent rapid technical development into effective weapons systems. Design work progressed from

15. D.A. Armstrong, *Bullets & Bureaucrats* (Westport, Greenwood Press, 1982:26)

16. NRAA, *Civil War Small Arms* (1960:18); & J. Dunn, "The Marlin Ballard Rifle", *Australian Shooters Journal* (April 1987:36-39)

17. NRAA, *Civil War Small Arms* (1960:21)

18. IBID:15

the Jennings Repeating Rifle design patented in August 1848 by Walter Hunt and Lewis Jennings,(19)(See Appendix 20, Patent No. 6973) to the early Volcanic Rifle patented in 1854. In turn, these early designs were taken by the Winchester Company and in 1861 they had, with their research and development, produced the Henry rifle.

The Henry repeating rifle had some design features that were to prove invaluable to later weapons.(See Appendix 21 & 22 on the Winchester design evolution) It used a lever action to continually feed into the chamber, rounds that were housed in a magazine tube mounted under the barrel. Although somewhat delicate in design, the weapon was extremely popular with those who used it. The technical success of the Henry repeating rifle is held by some to be the peak of Civil War small arms design. It built on the preceding design and combat success enjoyed by the Spencer seven-shot repeating rifle. Both designs utilized the lever action and self-contained ammunition.

The Model 1861 Spencer was, however, by far the most important repeating small arms design of the Civil War. Some 106,667 of these "most notable shoulder weapons"(20) were purchased by the end of the war. Feared by the Confederates as the rifle that could be "loaded on Sunday and fired all week", (21) the weapon had a reliable lever action that fed rounds from a seven-round magazine located in the butt. The design represented the best small arms technology mass-produced in the North.

Although the North produced the most successful breech-loading weapon innovations, the South was not without innovative genius, even if it did lack the subsequent production capacity and resources to convert ideas into physical realities. One interesting and ingenious concept was for a repeating rifle design called the Sibert magazine repeating rifle.

The Sibert was given a patent one month after the Civil War began. It would appear that early in the war all the costing on preliminary production and development of the weapon had been done.(22) The available documents indicate that the design was based on fairly conventional technical knowledge. Using a number of breech-loaded single barrels that rotated into alignment with the bore, the rifle could fire rounds in quick succession.(23) Because the weapon was such a departure from existing designs and required special manufacturing machinery, the Sibert seems never to have advanced

19. Butler, United States Firearms (1971:213-214)

20. The Gun Digest (12th Edition) (New York, American Publishing House, 1958:192); & Butler, United States Firearms (1971:226)

21. Butler, United States Firearms (1971:111)

22. C.E. Fuller & R.D. Steuart, Firearms of the Confederacy (Huntington: West Virginia, Standard, 1944:204-207)

23. IBID:204

beyond the design phase. The design certainly does not depart from established design principles in existence prior to the Civil War.(24)

Only with one magazine-fed small arm innovation can it be said that the Confederate Army's technical endeavour paralleled the North's. This was the development of the rapid fire gun.

The concept of a rapid-fire "shrapnel cannon" was not new. In 1859 the French had adopted the multi-barrelled Mitrailleuse (or 'grape-shot shooter') as a mobile rapid-fire, light artillery piece.(25) The design of an American single-barrel machine-gun was also not novel. The Agar ('Coffee Mill' or 'Union Repeating Gun') design predated the war. This weapon was a rapid-fire gun with a hand-crank mechanical operation and a top feed ammunition hopper.(26)

During 1862, Captain R S Williams, CSA, and Dr Richard Gatling had production models of their weapons field tested. The CSA Williams Rapid-Fire Gun and the Northern Gatling Gun saw service on a limited basis at the Battle of Seven Pines (Virginia), and Petersburg respectively.(27) Both designs represent a distinct divergence from usual military technology.

The innovative environment of the Civil War saw inventors in the North gradually evolve other repeating guns such as the horizontally mounted, twenty-four barrel Billingham-Requa Battery Gun, the eighty-five barrel 'Pepper Pot' Vandenburg Volley Gun, and other less effective designs that used light steel or brass cartridges to facilitate new mechanical actions.(28)

In the South the Chief of the Ordnance, Major-General Josiah Gorgas, produced a smooth-bore, rapid-fire gun that fired large metal case canister shot or solid shot from an eighteen-chamber rotating magazine.(29) As with the early Gatling Gun Model 1862 design and the Williams rapid-fire gun, all these weapons, although novel in their design features, failed to gain wide acceptance, due either to their mechanical deficiencies or because they failed to produce convincing weapon systems that could fit traditional military tactics.

24. See C. Blair (ed), Pollard's History of Firearms (New York, MacMillan, 1983:205-206 & 213)

25. I. Hogg & J. Batchelor, The Machine-Gun, (London, Phoebus, 1976:6-7)

26. IBID:4-5; & J. Coggins, Arms & Equipment of the Civil War (New York, Double Day, 1962:43)

27. Coggins, Arms & Equipment (1962:45); & C.B. Colby, Civil War Weapons (New York, Coward-McCann, 1962:18)

28. Armstrong, Bullets & Bureaucrats (1982:24-25)

29. Colby, Civil War Weapons (1962 192)

Although the Gatling Model 1862 was prone to breakdowns, twelve of the design were purchased at \$1000 apiece and used by General Butler.(30) The weapon showed that it had great potential against massed close-range targets. Therefore, when the perfected Model 1865 was introduced with four or six barrels, a more efficient feed system, using metallic cartridges and working efficiently with 1 inch or 0.50 calibre rounds, the War Department and the Navy immediately adopted the weapon.(31) (See Appendix 24)

It is perhaps indicative of arms development during the war that it was the North that could best develop and update weapons technology that was to remain in service until the first decade of the twentieth century. The Williams Gun stands as an example of the CS Army's basic failure to modify a sound design. The most serious design problem of breech expansion, that occurred with continuous firing, could have been alleviated by the use of better metallic ammunition and an improved extraction systems.

The North with its superior industrial capacity was clearly better able build on existing technical knowledge and produce a commercial product. Even failure to sell the product could further spur innovators and industry to improve upon other technology. In the South, the ingenuity of innovators was not matched by such a capacity to convert technical knowledge into better weapons systems. Testimony to this is the fact that the only weapon purposely designed and mass-produced in the South during the war, was a 0.58 calibre muzzle-loading carbine produced between 1864 and 1865.(32)

The industrial capacity of the North did not however necessarily guarantee it an absolute advantage in developing new or better weapons. Both sides, for example, depended upon percussion revolvers throughout the war; (See Appendix 6) this was despite exposure to some foreign designs with novel features, the patenting of repeating revolvers (See Appendix 20), and the American development of a rimfire 0.22 calibre revolver by Smith and Wesson based on the April 1855 patent of Rollin White.(33)

It would seem that in the technical advancement over previous knowledge, breech-loading and repeating rifles represent the greatest development in wartime small arms technology. For while the machine-gun and revolver held real potential, it was the evolution in breech-loaders and repeating rifles that achieved the most significant success in replacing older small arms technology. During the course of the war, technical attitudes changed from an almost religious reliance on muzzle-loading

30. Hogg & Batchelor, The Machine-Gun (1976:7); & The Gun Digest (1958:21)

31. Hogg & Batchelor, The Machine-Gun (1976:7)

32. W.S. Hoole, "The Confederate Armory at Tallassee, Alabama, 1864-1865", The Alabama Review (Vol.25[1], January 1972:4)

33. Patent No. 12648 bored through cylinder to use rim-fired rounds see E. Ezell, Handguns of the World (London, Arms & Armour, 1981:35); & Blair, Pollard's History of Firearms (1983:318-325)

muskets to a stage where, at the end of the war, breech-loading rifles were the preferred standard small arm desired by field commanders and soldiers.

Muskets used at the end of the war were far more advanced than their flintlock predecessors, which had been mostly cast-off during the war. However, the Spencer, Sharps and Henry breech-loading rifles were a quantum leap again over rifled muzzle-loading musket technology. By the end of the Civil War it was these technological advancements incorporated in small arms, that were being consolidated into a new standard for the military.(34)

2.2 Breech-loading Cartridge Ammunition

The development and actual use of the centre-fire cartridge in the American Civil War was a major step towards modern ammunition and modern warfare.(35) The chief reason for this interest in perfecting cartridge ammunition in American small arms manufacturers, can be traced back to the Hall's breech-loading flintlock. This weapon instilled the desire to create ammunition for the new generations of percussion breech-loader designs, that were to evolve in the two decades prior to the Civil War.

The impetus for breech-loading cartridge ammunition was the muzzle-loading cartridges made for muskets or rifle muskets of the 1850s. In particular, the combination of the rifle-musket and the minie ball proved the advantages of uniting the ball and black powder into one unit. (See Appendix 1) Developments in muzzle-loaded cartridges also led to the development of rounds that were adapted for use in breech-loaders. These included unorthodox designs such as the Williams Bullet, the Shaler Sectional Bullet, the Gardiner Explosive Shell, and the 0.44 Colt (paper) Bullet.(36) (See Appendix 2)

To the development in muzzle-loading cartridge ammunition during the war, can be added technical development in cartridge ammunition prior to the war. These advances include, in 1848, the "rocket ball" metallic cartridge designed by Walter Hunt. This was followed by the 0.54 Hunt breech-loading repeating rifle. In turn, development became centred around the joint development of breech-loaders and their particular cartridges. Prior to the war this development produced the Model 1840 Hall carbine and 0.64 paper cartridge; the 1856 Gibbs 0.52 calibre carbine and the 1854 Greene 0.54 calibre carbine, which both fired early paper cartridges; the Sharps carbine and 0.56 paper cartridge and later linen cartridge; the Maynard 1859 Model and its distinctive

34. Armstrong, Bullets & Bureaucrats (1982:27)

35. The Gun Digest (1958:9)

36. B.R. Lewis, Notes on Ammunition of the American Civil War 1861-1865 (Washington, American Ordnance Association, 1959:4-10)

0.50 calibre brass cartridge with a broad-rimmed base and fitted percussion cap; and the 1860 Burnside carbine with its tapered-cone brass cartridge with a fitted percussion cap. (See Appendix 3)

Technical developments in breech-loading cartridges produced cartridges composed of different materials, from nitre-soaked paper to ordinary paper, cardboard, linen, skin, rubber, copper, and brass. As with ordinary muzzle-loading cartridges, which had innumerable variants in calibre (from 0.31 to 0.79) and performance, the breech-loading ammunition also had different characteristics. (See Appendix 4 & 5) To make matters more confusing the development of the machine-gun, repeating breech-loader rifles, and revolvers also produced novel cartridge ammunition. The Requa 0.54 calibre brass cartridge, the Spencer 0.52 calibre rimfire copper case and the Henry 0.44 rim-fire copper case; and the Smith and Wesson 0.22 or 0.32 calibre rimfire revolver round, broadened the successful use of metallic cartridges to all types of small arms.

The development of ammunition was linked to new small arms development. This resulted from the attempt to find a combination of an arm and round that would overcome gas leakages from the breech mechanisms.⁽³⁷⁾ The successful evolution of technical knowledge on breech-loading ammunition can best be traced through the types of breech-loaders and their cartridges used during the Civil War. This also illustrates the role technical evolution in ammunition played in making new rifle designs more effective and efficient. There existed five basic phases:

- (i) **Primitive:** separately primed cartridge with percussion cap or patent primers and a separate combustible envelope – Colt, Gibbs, Greene, Gwyn & Campbell, Jenks and Merrill, Joslyn (percussion model), Lindner, Merrill, North-Hall, Perry, Sharps (early model), and Starr.
- (ii) **First Transitional Type:** a percussion breech-loading with an auxiliary Maynard type primer magazine as well as nipples – Burnside (early model), Greene, Jenks (Remington), Maynard (early model), Merrill (early design by Merrill, Latrobe and Thomas), and Sharps (models 1851 and 1855).
- (iii) **Later Transitional Type:** primed by percussion caps or patent primers but with perforated metallic or rubber cartridge case – Burnside, Gallagher, Maynard and Smith.
- (iv) **Wartime Developments:** rim-fired types completely self-contained in metallic cartridge – Henry, Ball, Ballard, Joslyn, Palmer, Remington, Sharps (Model 1863), Sharps and Hawkins, Spencer, and Warner.⁽³⁸⁾

37. Davis, Arming The Union (1973:121); & Armstrong, Bullets & Bureaucrats (1982:32, 35 & 37)

38. Patterson & De Maco in NRAA, Civil War Small Arms (1960:15)

- (v) **Wartime Design Variants:** the centre-fire cartridge types with fulminate either in the rim and centre or centrally located primer self-contained in the cartridge – Smith Carbine (Crispin patent), La Fauchaux (revolver), La Mat (revolver), Raphael and Perrin (hand guns).(39)

The fifth phase illustrated the limited use of centre-fire cartridges. However, in the centre-fire design of Colonel Hiram Berdan (of Berdan's Sharpshooters fame), with a separate primer assembly pressed into a pocket formed in the centre of the cartridge head, ammunition attained a configuration that has changed little today.(40) This round was refined and developed by Colonel S V Benet, Commander of the Frankford Arsenal in 1864 and 1865. The development and manufacture of such complex cartridges was difficult and caused serious restriction on experimentation and research. Conversely the success of the Spencer breech-loader and its ammunition can be attributed to the fact that they were the most easily manufactured of the designs in the family of new small arms and cartridges.

An example of the failure to develop ammunition because of its "parental" breech-loading design's failure to gain acceptance, is the 0.44 Henry rimfire. Described as the most important "final breakthrough in rifle ammunition during the Civil War", (41) the ammunition – along with its repeating rifle – failed to gain Federal contracts when introduced in 1862.

The rifle did have some design weaknesses, yet when tested by a United States Naval lieutenant attached to the Ordnance Bureau it fired 120 rounds of ammunition in 340 seconds without a stoppage or misfire.(42) Although a remarkable feat for the day, the rifle and ammunition did not impress General James Ripley, the then Head of the Ordnance Bureau. Thus it was left to individual soldiers and State militias to purchase the majority of the 10,000 Henry rifles produced during the war. Despite official reluctance, the eventual success of the design is evidenced by Federal records which show 4,610,400 Henry 0.44 calibre rimfire cartridges had to be supplied to Northern forces.(43)

It is a testament to the technical development of the breech-loading cartridge, that despite restricted introduction of breech-loading carbines, some 55 million rounds were still officially purchased.(44) The existence of these rounds enabled ancillary developments such as greater concentration on designing better repeating rifles. These new rounds also enabled innovators to adapt earlier, less successful designs, such as the

39. Blair, Pollard's History of Firearms (1983:330–331)

40. Butler, United States Firearms (1971:114–115)

41. Butler, United States Firearms (1971:109)

42. F. Wilkinson, The World's Great Guns (London, Hamlyn, 1977:171)

43. Lewis, Notes on Ammunition (1959:29)

44. IBID

Gatling Gun, to overcome design weaknesses. This promoted the concentration of designs around standard calibres of ammunition.

Whilst such advances were made in the North, little was achieved in the South. Some advantages did lie in standardisation of arms and the ammunition used by issued arms. This was due to the fact that the South was forced to maintain small arms that were almost exclusively of pre-war design, again reflecting the degree of technical underdevelopment of the CSA compared to that of the US Army. This point is further highlighted by the Confederates' inability to utilise captured Sharps, Spencer, Henry and Ball rifles because their post-1863 ammunition designs were beyond their manufacturing techniques. Shortages of resources aside, the South's pre-war production facilities were too primitive even to be converted to produce this ammunition, had they the time and resources available to do so.

Despite the South's lack of contribution to cartridge ammunition development, and in spite of the difficulty faced by Northern ammunition innovations trying to get adopted, Civil War ammunition development was remarkably successful. The shape of ammunition (rimfire and centre-fire rounds in particular), the moulding of bullets, and the use of brass and copper cases, all reflect developments consolidated for the first time in the Civil War and still in use. It was only in the inferior black powder and nitre loading of cartridges, that post-Civil War arms innovators were able to make significant advances prior to the twentieth century.

The technical change to Civil War breech-loading ammunition, therefore, saw its design integrity consolidated over paper and ball ammunition whilst also attaining design features that are still recognisable in ammunition produced a century later.

2.3

Civil War Railroads

Any discussion of Civil War technical innovations inevitably leads to an examination of railroads and ironclad warships and how they came to be martial representations of the industrial age. On land, the railroads were seen as living symbols of the new steam powered era and a representation of the changes wrought in contemporary technology. Yet, more than any other innovation in land warfare, technical advancement in railroad technology remains difficult to measure. Mostly restricted to improvements or adaptations that satisfied local military needs, railroad technical development has even been perceived to have produced no technical innovations. But is this a fair assessment?

It is important to note that most Civil War railroad innovation drew heavily on existing technical knowledge. Nonetheless, it is important to establish if the innovations were more than just random and unimportant adjustments to existing technology.

The foremost role of rail in the Civil War was in its logistical capacity to re-supply armies. Rail expedited the delivery of men, munitions, clothes, medicine, food and forage whilst facilitating the removal of the wounded, prisoners, refugees, and captured material.(45) This role had been experimented with in Europe in the 1859 Franco-Austrian War at Solferino, yet the Civil War was the first time the tactical benefits of moving troops rapidly were fully realised.(46) Rail's ability to rapidly relocate men and material introduced a whole new dimension into military strategy.(47)

The incentives for both Federal and Confederate Governments and military commanders to create a unified rail system were enormous. To the owners of the rail lines and manufacturers of rolling stock, the war also produced commercial rewards that spurred the advancement of co-ordinated rail links.(48)

A number of significant technical innovations can be traced back to this desire to facilitate an efficient rail supply system. The Union standardisation of rail gauge at four foot eight-and-a-half inches (49) was accompanied by improvements to the road beds and more flexible and better designed rolling-stock bogies. Better rail lines (including steel lines) were introduced late in the war, and steam engines became functionally more efficient, whilst their manufacture became correspondingly easier.(50) These technical innovations were complemented by engineering developments such as the building of prefabricated trusses and standardised rail construction and destruction techniques.(51) Together they enabled the Northern wartime railroads to fill the military demands constantly placed upon them.

Aside from the desire to create a functional network of rail lines, both the North and the South also produced the innovations in railroad rolling stock necessary to satisfy specific needs. In particular there were significant special designs, including trains specifically used to remove wounded, armoured trains, and telegraph trains.

The First Bull Run battle marked a major phase in the use of rail by the Confederate Army to bring up men and artillery from its reserves and directly deploy them into battle against the Union forces – an early attempt to exploit rail's tactical value in

45. A. Nevins, The War for the Union (Vol.II) "The War becomes Revolution 1862-63" (New York, Charles Scribners, 1959:460)

46. M. Howard, War in European History (London, Oxford University Press, 1976:98)

47. G.E. Turner, Victory Rode the Rails : The Strategic Place of the Railroads in the Civil War (Connecticut, Greenwood Press, 1972:45)

48. G.R. Taylor, The Transportation Revolution, 1815-1860 (New York, Harper Torchbooks, 1951:98-99)

49. G.R. Taylor & I.D. Neu, The American Railroad Network 1861-1890 (Massachusetts, Harvard University Press, 1956:55)

50. Taylor & Neu, The American Railroad Network (1956:1); & Taylor, The Transportation Revolution, 1815-1860 (1951:81-83)

51. G. B. Abdill, Civil War Railroads (New York, Bonanza Books, 1961:30,38,40, & 56-57)

outmanoeuvring an enemy. As well, this battle also represented the first large-scale use of trains to remove wounded from the battlefield. Although it was carried out in an unorganised manner on standard rolling-stock, the advantages were apparent. What was to emerge was a more deliberate use of designated trains to remove Northern casualties systematically. These experiences inspired special innovations. Hospital rolling-stock was specially manufactured with good ventilation, lighting, and heating. Experiments were carried out with standard stretchers being slung upon shock-absorbing heavy rubber bands and also with the inclusion of small operating theatres capable of performing minor surgery.(52)

Although normal trains were often used, when hospital trains were available to Northern forces they greatly enhanced the survival chances of casualties. Later improvements with passenger cars instead of box cars and better equipped surgical cars, also increased the care available to the wounded. At Chattanooga, Dr Barnum (US Army) supervised the rail transportation of 20,472 patients on hospital trains and lost only one man en route.(53) After Gettysburg from 1 July till 1 August 1863, 15,580 wounded were moved by rail to Baltimore, New York, Harrisburg, or Philadelphia.(54) In total, Northern hospital trains from 1862 to 1865 removed some 225,000 wounded or sick of both sides directly from the battlefield.(55)

Although few records exist with which to construct a picture of the South's use of rail to remove wounded, it is known that it had no organised system of specialised hospital trains.(56) As the war progressed its rail system degenerated under the ravages of war. The South's inability to replace-rolling stock or rail lines made systematic attempts to remove wounded by rail almost impossible.

In the area of technical development associated with armoured trains, the South at least kept pace with Northern initiatives. Armoured trains included those made shot-proof to protect locomotive firemen and drivers from ambushes and sniper fire, those adapted to carry troops and even cannon to deter guerilla attack, and trains armed with heavy artillery to provide mobile artillery support for friendly forces.(57)

Bullet-proof trains seem to have been manufactured by both sides. Using available materials such as wood, sandbags, old rail girders, building materials, or parts from

52. IBID:78; & Turner, Victory Rode the Rails (1972:300)

53. Turner, Victory Rode the Rails (1972:303)

54. United States – Military Railroads Department, Report of Brevet Brigadier General D.C. McCallum (Washington, US Army, 1866:7); & E.A. Pratt, The Rise of Rail-Power : In War & Conquest, 1833–1914 (London, King & Son, 1915:87)

55. Abdill, Civil War Railroads (1961:78)

56. Turner, Victory Rode the Rails (1972:309)

57. Pratt, The Rise of Rail-Power (1915:68)

destroyed rolling stock, trains were given added protection. Although many trains could well have had specially machined extra protective armour added, there apparently existed no co-ordinated efforts in the North or the South to construct armoured trains. It was more likely that, as was the case with the provision of special rolling-stock for men or horses to protect trains, adaptation of available rolling-stock occurred.

Unlike other types of armoured trains, rolling-stock with mounted guns did receive at least a degree of concerted innovative, as opposed to adaptive, technical change. Derived from the principle of using large calibre ordnance on rail to give mobile coastal defence, 'rail guns' were used in numerous forms throughout both armies and in all theatres of the war. Although mostly designed around existing rolling-stock, the marriage between coastal or naval guns and their mounts, produced various design differences.

Specific effort was made to engineer carriages and guns into a weapons system with some combat utility for land forces. Records exist of the Confederates successfully deploying a Brooke, Seacoast or Naval 10-Inch smooth-bore on a flat tray in the Peninsular Campaign of 1862.(58)(See Appendix 7) It was the use of a Confederate rail gun at Jacksonville in March 1863 that precipitated the first recorded rail gun duel. The Brooke 10-Inch Confederate rail gun was opposed and forced off the battlefield by counter fire from a Northern 4-Inch rifled breech-loader specially mounted on a flat tray to chase the Confederate piece.(59)

However, the best representative example of Civil War rail guns occurred at Petersburg. It was there that the North deployed the "Dictator" or "Petersburg Express", a huge 13-Inch Seacoast Mortar Model 1861, which weighed 17,000 pounds and fired a 200-pound shell.(60) Its mobility and firepower enabled the Northern forces to engage Southern targets with some initial success.(61)

An important method of aiming rail guns has been traced back to this battle. The practice of placing a rail gun on a curved track to give an arc of fire (5.5 inch traverse for every 88 feet moved down a track with a 500 foot radius) was utilised by the

58. Coggins, Arms & Equipment (1962:114); W. Ripley, Artillery & Ammunition of the Civil War (New York, Van Nostrand Reinhold, 1970:130); & Abdill, Civil War Railroads (1961:93)

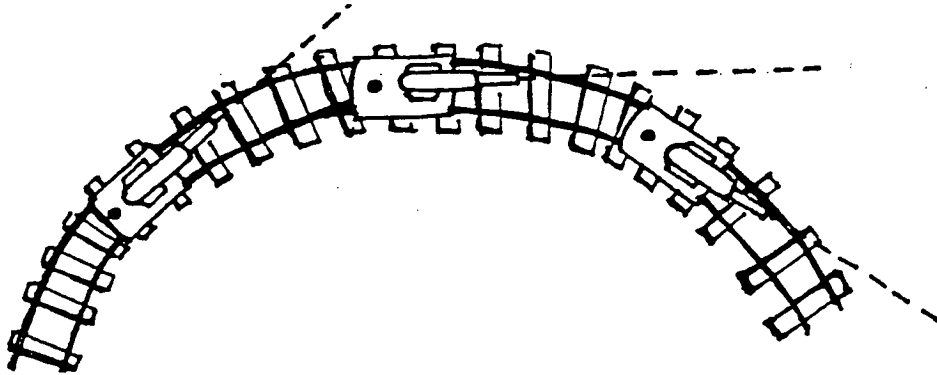
59. Abdill, Civil War Railroads (1961:93)

60. IBID:106

61. IBID:93; & Ripley, Artillery & Ammunition of the Civil War (1970:129-131)

"Dictator" and utilised by rail guns up until they became outmoded in the mid-twentieth century.(62)

Figure 3



The technical adaptation of the train to accept military telegraph equipment is the final important innovation made to rolling stock. These innovations involved the use of trains to carry a Beardslee magneto-electric telegraph machine.(63) By 1863 thirty of these trains were in use by the Union forces as relay points for short-range field telegraphs. They acted as central points where command centres could be established, with telegraph wires laid out to link forces spread up to eight miles away.(64) Brigadier General D C McCallum, who was in charge of Northern railroads, and Major A J Myers, Controller of the military telegraph system, both promoted the employment of the telegraph train and ensured it received specially converted new or undamaged rolling stock.(65)

Technical changes to railroads accompanied most adaptations of trains to meet military needs. As the needs were never expressed in a systematic manner or rarely attained in a controlled and co-ordinated way, most technical innovations were merely minor or incremental improvements. Yet, these changes, although often sporadic and un-orchestrated, did enable railways to supply mass armies dispersed across wide

62. C. Chant, How Weapons Work (London, Marshall Cavendish, 1980:60); & Ripley, Artillery & Ammunition of the Civil War (1970:65)

63. W.R. Plum, The Military Telegraph: During the Civil War in the United States (Vol.II) (New York, Arno Press, 1974:90)

64. Scheips wrote the introduction to Plumb, The Military Telegraph (Vol.II) (1974:v)

65. IBID::Introduction

areas,(66) successfully remove casualties, and give mobile artillery and telegraph support to military forces.

Admittedly, the growth in technical knowledge was secured through innovations that involved minor changes to the basic technology of rail travel. Rather, the war provided the inspirational spur that amended the use of rail and its technical components so it could more efficiently fill growing military demand.(67)

Technical innovation during the Civil War cannot be said to have stagnated but rather to have been restricted to a number of small changes that did not produce radical technological shifts. These innovations were in turn based on the great amount of pre-war technical development associated with the great expansion of American railroads during the 1840-to-1850 period.(68)

The Civil War concentrated innovative development on making pre-war rail technology more able to meet military demands placed upon it.

2.4

Balloons

The development of aeronautics as a legitimate tool in warfare owes much to the use of balloons in the Civil War. This development of aerial warfare has been advanced as an indication that the Civil War was unlike preceding wars, establishing the war's link with the era of modern warfare.(69)

Balloon technology was well-advanced prior to the Civil War. Parallel to this pre-existing technological development was the evolution of the military use of balloons in war. The question as to how Civil War use of balloons affected military technological change can only be fully answered after an examination of how balloons were used in the war and how technical changes facilitated their greater utilisation.

It cannot be said that the Civil War marked a radical beginning to the technical knowledge derived from the use of balloons in war. Only four months after the invention of the balloon by the Montgolfier brothers in France on 5 June 1783, Jean Francois Pilatre de Rozier ascended in a balloon (on 15 October 1783) and immediately advocated its introduction as a tool of war.(70) Prior to 1861, balloon technology was

66. E. Risch, Quartermaster Support of the Army : A History of the Corps 1775-1939 (Washington DC, Office of the Quartermaster General, 1962:365 & 404)

67. A. Fishlow, American Railroads & the Transformation of the Anti-Bellum Economy (Massachusetts, Harvard University Press, 1965:305)

68. Taylor, The Transportation Revolution (1951:75-85); & Fishlow, American Railroads (1965:154)

69. F.S. Haydon, Aeronautics in the Union & Confederate Armies: With a Survey of Military Aeronautics Prior to 1861 (Vol.I) (Baltimore, Doctoral Dissertation, 1941:xvi)

70. IBID:2

developed hand-in-hand with its military utility. It had been used by the French for aerial observation at the Battle of Fleurus and was used in an organised Regular Balloon Company formed on 2 April 1794.

Since the inception of the balloon a number of suggestions had been made on how to use aeronautics in offensive operations. Ingenious ideas were formulated for using the balloon to bomb impregnable forts and numerically superior land and naval forces. In the Crimean War these ideas were pursued by both sides when the British and the French attempted to bomb the Russians at Cronstadt and were later subjected to Russian attack from captured balloons.(71) These early military roles were transferred across the Atlantic in July 1846 when, during the Mexican War, ballooning was used in conjunction with other military endeavours. One proposal, contrived by the American forces, was to use John Wise's balloon to bomb the fortress of Vera Cruz.(72)

Technical development of the balloon in America reached a pre-war climax with T S C Lowe's historic attempt to cross the Atlantic in a 700,000 cubic foot balloon, "The City of New York." This feat occurred in a period of highly publicised aeronautic efforts that created not only a spur to greater technical achievements, but wide acclaim for pioneers of ballooning such as James Allen, John Wise, John La Mountain, and Thadeus Lowe.(73)

When the war commenced these pioneers were responsible for trying to introduce aeronautical technology into Northern military service. The War Department undertook to evaluate their offers. Unsure of the practical military uses of balloon technology, the War Department engaged the eminent scientist Joseph Henry as a technical consultant.(74) His recommendation not only endorsed the use of balloons in war but also gave full endorsement of T S C Lowe's efforts.

From very early in the war it was evident that balloons could be used as an adjunct to land forces. Throughout the war, however, its role in both the Northern and Southern forces was mostly limited to non-aggressive actions. Its use was mainly restricted to reconnaissance, topographical survey, vital cartography information, spotting enemy troop movements before and during battle, signalling, and artillery observation.(75)

71. IBID:20-21

72. IBID:28-29

73. J.D. Squires, "Aeronautics in the Civil War", American Historical Review (Vol.13[4], 1937:660)

74. A. Hunter-Dupree, Science in the Federal Government (Massachusetts, Belknap Press of Harvard University Press, 1957:128)

75. Squires, "Aeronautics in the Civil War" (1937:662-663)

The North's early attempts to deploy balloons met with little success. On 8 and 14 July 1861, James Allen failed to make ascents because a lack of hydrogen prevented him from inflating the balloon. John Wise's balloon was inflated and deployed at the first Battle of Bull Run. Because free flight was not considered possible, attempts were made to redeploy the inflated balloon by towing it with a cart. The decision to tow the balloon across wooded countryside was made by the aeronautically naive Major Myer (who later went on to command the Signal Corps). Inevitably, the balloon struck trees and had a hole torn in envelope.(76)

On 31 July 1861, however, John La Mountain successfully put to air for General Butler at Hampton. Once aloft he spotted a concealed water battery (river minefield) at Sewall's Point and observed significant enemy force build-ups in the area.(77) In this case continued observation was shortened, by the lack of available hydrogen and supporting equipment.

The development of Confederate aeronautics seems to have occurred mostly in response to the North's successful use of balloons. Unlike the North, which progressed between late 1861 and mid-1863 to purposely built up-to-date balloons, the South was restricted to crude manufacturing techniques. Most Southern balloons were made from silk or fine linen salvaged from old frocks, and crude rope and baskets had to be constructed in the field. Nevertheless, these dubiously constructed designs were deployed successfully in the front lines and were even used on naval vessels in key strategic river positions.(78)

Balloons provided invaluable assistance to artillery batteries that had an over-the-horizon range and therefore needed more accurate fire control.(79) In the North, although artillery observation was also a major use for balloons, there occurred technical developments in ancillary areas that overcame early design problems.

Balloons could provide vital battlefield intelligence. To enhance this role an accurate and swift form of delivering information from the balloon observer to the ground had to be devised. Early use of written messages or sketch maps, weighted with heavy objects and dropped to the ground, proved inefficient, while the use of signal flags or flares lacked the precision necessary to convey complex messages. At this point the technical knowledge on the balloon and existing telegraph systems were linked together, to give a highly accurate means of communicating orders and observations.(80)

76. Haydon, *Aeronautics* (Vol.I, 1941:48-49, 70-71 & 139)

77. *IBID*:93-94)

78. M.F. Perry, *Infernal Machines* (Baton Rouge, Louisiana State University Press, 1985:18)

79. Chant, *How Weapons Work* (1980:52)

80. As early as June 1861 T.C.S. Lowe had successfully demonstrated his balloon and while he was in flight, sent President Lincoln a telegraph.

Advances in research into providing accurate battlefield observation, were not, however, all successful. Dr John W Draper, a member of the fledgling American Photographical Society, together with colleagues of the American National Academy of Science, tried to get the War Department to conduct experiments with balloon-mounted cameras.(81) This attempt to experiment with the marriage of these two technologies, however, never gained official endorsement.

Major technical problems were also associated with the inflation and deployment of balloons. These problems were compounded by the difficulty of transporting balloons and their equipment across the wooded countryside, over which the Civil War usually raged. The breakthrough came with the introduction of a mobile gas generator.

It has been claimed that La Mountain was the first to produce a forerunner of later generators that could inflate balloons quickly without all the previously required cumbersome equipment.(82) However, it was T S C Lowe who designed the first portable gas generator that was to produce a lasting change in aeronautics.

His design was based upon the knowledge that hydrogen could be produced from the interaction of sulphuric acid and iron. By 1863 this design was further developed, permitting balloons to be filled by mobile gas generators in three hours, instead of the normal twelve or more hours.(83) Although the innovation built upon La Mountain's generator and pre-existing knowledge of producing hydrogen from iron and sulphuric acid, it did so in a manner that, Lowe argued, produced a wholly new piece of technological innovation.(84) It was this development that in turn gave balloons new mobility and enabled more rapid deployment.

As the abundance of woodlands restricted the use of balloons on land, Civil War aeronauts took their balloons into the sphere of the navy. Rivers were used to convey balloons to front-line military operations. Drawing from their experiences with mounting balloons on sea craft during Atlantic crossings, the difficulty in marrying balloon technology with existing naval technology was confronted.

Craft were converted specifically to carry balloons for reconnaissance; these included the G W Parke Custis by the North and the CSS Teaser by the South. This was negated

81. Haydon, Aeronautics (Vol.I, 1941:332)

82. IBID:139

83. IBID:250

84. Official Records, "The War of the Rebellion, A Compilation of the Official Records of the Union & Confederate Armies" (Washington D.C., Government Printing Office) (Series III, Vol. III 1899:317)

to some extent as these vessels often lacked personnel with sufficient expertise, or had to deal with naval commanders who had unrealistic expectations for the balloon's use.(85)

Listing the expense of balloon operations and the belief that they made no significant contribution to the war, in the military hierarchy ensured no attempt was made to organise observation flights or issue specific mission statements.(86) A number of technological shortcomings that limited military acceptance of balloons could have been overcome with more technical development.

Despite the fact that severe winds often made balloons unusable, there was no attempt to encourage scientific work in wind movements or actually restrict ascents. A further complaint by military commanders of both the North and the South was that balloons attracted enemy fire, thus giving away defensive positions. This objection was voiced despite the fact that balloons could be used in free flight or, through improved liaison within the army, could be located in safe areas. The controlled and more limited use of balloons could also have been coupled with visual aids such as the telescope to safely improve observations from the air.(87)

Despite support from such prominent Northern generals as McClellan, Fitz John Porter, and Butler, and political leaders including President Lincoln, the Balloon Corps did not survive the army re-organization of mid-1863. Coincidentally, the use of balloons in the North as in the South, became increasingly unco-ordinated.

The use of the balloon in the Civil War was, then, facilitated by technical innovations that improved it as a technological entity and helped it attain greater military utility. Even with technical improvements, which occurred throughout the war, the balloon's position could not be consolidated in the armies of the day. Existing as an outrider body attached to separate army groups but responsible to Head Quarters administration, the Balloon Corps was caught in a malaise of organizational uncertainty. Civil War balloon use was characterized by its failure to establish itself as an indispensable part of land forces. Thus it may be said only to have established itself as a practical example and applied demonstration, of the potential for aeronautical innovation.

85. Civil War Naval Chronology 1861 - 1865 (Washington DC, Naval Department, Part I, Undated:34-37)

86. Command structure versus the Head Quarters, see, Official Records (Series III, Vol. III 1899:295-298)

87. Squires, "Aeronautics in the Civil War" (1937:663)

2.5

The Telegraph

The American Civil War was the first war in which the field telegraph was extensively employed. Due mainly to the size of the participating armies, the vast distances over which the war was spread, and the fluidity of the fronts, the military telegraph quickly received wide recognition in both major armies.

As with other technologies so far examined, the foundation for the telegraph's use in the Civil War was laid prior to 1861. Between 1837 and the 1850s the Morse telegraph was perfected and electric telegraphy became commercially viable.⁽⁸⁸⁾ The telegraph line also spread alongside rail lines, as they expanded with America's growth.

During the Crimean War these developments enabled the British to use the telegraph as an inter-communications device. In the Mexican War the US Army's use of the telegraph was pursued by A.J. Myer who tried to circumvent the problems of conventional visual signalling (by flag, flare, rocket and fire).

These pre-war efforts produced an awareness in America of the telegraph's military function, that later stimulated interest when the Civil War began. Acceptance of the technology and resistance to its introduction were certainly reduced because practical use had "resolved most, if not all, of the elementary facts" that became the technical basis for the Civil War military telegraph.⁽⁸⁹⁾

The introduction of and heavy reliance upon the telegraph, were however brought about by expediency, rather than design efficiency. The use of pre-existing civilian lines their civilian operators promoted military control of the service. Finally, in October 1861, President Lincoln formally recognized the incorporation of railway telegraph operators into military service. On 26 February 1862 he gave the military priority in line usage and line construction,⁽⁹⁰⁾ but it took until August 1864 for a distinct U.S. Military Telegraph Corps to be made separate from the Signal Corps, which itself had been officially instituted only in March 1863.⁽⁹¹⁾

Organizational consolidation was possible as the degree of technical specialization in the telegraph continued. The development of a truly mobile field telegraph, the 'mule pack' telegraph, became possible with the introduction of smaller batteries, that was only half the weight of the old 100-pound types.⁽⁹²⁾

88. Plum, The Military Telegraph (Vol. I) (1974 :24)

89. IBID

90. Schcips IBID:ii

91. Coggins, Arms & Equipment (1962:106)

92. Official Records (Series III, Vol. III 1899:979-980)

A further technical development was an improvement in the quality of insulated wire. This enhanced not only transmission quality, but also the range of communications. Another important innovative advance was the mounting of the Beardslee telegraph system on specially converted trains. These devices gave swift mobile 'command and communication centres' from which telegraph operations could be conducted.(93)

Linking the new Beardslee telegraph machine to trains, and then to telegraph lines, enabled operators to act as the central communications connection between field telegraph operators and the pre-war telegraph lines. The mule packs with their 15-mile or so portable insulated cables, could be linked to the trains and in effect to anywhere in the United States that was connected to the main telegraph lines.

In the North telegraphic communications were quickly enhanced. Between 1861 and 1865 some 15,386 miles of telegraph line were laid.(94)

In the South the military value of the telegraph was hindered by the lack of material to extensively introduce field telegraphs. Additionally, the lack of insulated wire seriously inhibited the installation of telegraph lines, further hindering military exploitation of any potential the lines may have held.

An interesting innovation brought about by both the North and the South's reliance on extensive telegraphic links, was the production of codes and ciphers. The encoding of messages and efforts to intercept and decode them, added a new dimension to military espionage practices.(95)

When discussing the telegraph as an instrument of change in military conduct, two other areas must be highlighted. Technical development of the field telegraph and short-range larger telegraphic equipment enabled defensive positions to respond very quickly to communicated orders. Also the rapid deployment of forces on the battlefield or by rail often depended on the use of the telegraph.

The telegraph was also instrumental in improving naval communications and operations. With the introduction of the telegraph the relaying of news from official reports or private individuals back to the population centres of America, improved.

Technical innovations in telegraphy were of inestimable value to the Northern forces, enabling them to retain communication links where the previously available means

93. Scheips in Plum, The Military Telegraph (1974:i-v); & Official Records (Series III, Vol. III 1899:980)

94. Scheips in Plum, The Military Telegraph (1974:i-v); & Official Records (Series III, Vol. IV 1899:361)

95. Plum, The Military Telegraph (Vol. I)(1974:35-37); & Coggins, Arms & Equipment (1962:107)

would have failed or would have been too slow. Correspondingly, in the South, pre-war telegraph lines had to carry the burden of communications as the war continued. As they lacked the necessary resources to repair or improve these lines, the system inevitably decayed and became inefficient.

CHAPTER 3 TECHNICAL CHANGE TO NAVAL WEAPONRY

Naval conflict is overlooked in favour of land battles when historians look for why the South was defeated. Yet it was the Federal Navy's ability to preserve General Winfield Scott's Anaconda Policy, blockading the Confederate States, that was to strangle the supply of materials necessary for the South to wage war.

The extension of the blockade through the Civil War resulted in attacks on coastal forts, combined operations to gain strategic positions, blockading harbours, controlling inland river systems, and finally attacking Confederate commerce raiders and blockade runners.(1) These strategic naval operations promoted an innovative environment where both sides sought to strengthen their tactical abilities.

It is in the growth of naval technical knowledge that the Civil War is often cited as contributing most to military technological change. The building and use of steam-propelled ironclad warships, and the development of torpedoes (sea mines) with their various delivery vehicles, have been seen to elevate the war into the forefront of ingenious endeavour.(2)

Prior to the war, the Naval Department had been exposed to the revolution in sea warfare, that by 1859 had seen the 5,600-ton French frigate Gloire launched, with its steam engine and four-and-three-quarter-inch thick iron plate covering its hull. By 1860 this form of naval development was confirmed with the Royal Navy launching HMS Warrior, which was a 9,000-ton, iron-hulled vessel with 4.5-inch thick iron plates. This class of Royal Navy vessel was followed in the next year by HMS Defence, HMS Invincible and HMS Royal Sovereign, all constructed with iron (and later steel) hull armour.

These developments had though, been presaged by advances in technology in America. As early as 1842, authorization had been given by the United States government for the construction of a 6,000-ton, 420-foot-long floating battery with ten large calibre cannons. It was also to have steam propulsion and armour plating.(3)

1. E.B. Potter & C.W. Nimitz (eds), Sea Power: A Naval History (New Jersey, Prentice-Hall, 1960:250); & B. Anderson, By Sea & By River: The Naval History of the Civil War (New York, Alfred A. Knopf, 1962:41)

2. Dupree in D.T. Gilchrist & W.D. Lewis, Economic Changes in the Civil War Era (Delaware, Eleutherian Mills-Hagley Foundation, 1965:Comments 133-134)

3. R. McBride, Civil War Ironclads: The Dawn of Naval Armour (New York, Chilton Books, 1962:8-9)

Construction of this "Stevens Battery" began but was never completed. However, in 1842, steam propulsion and the development of a screw propeller had been successfully incorporated in the John Ericsson designed USS Princeton.⁽⁴⁾ This vessel has been called "epoch-making" because so many of her features foreshadowed later design practices.⁽⁵⁾

Also, in ordnance the United States Navy had well-established research efforts. This research was enhanced, rather than deterred, by the explosion of the large calibre "Peacemaker" cannon on board the Princeton on 28 February 1844. The explosion of the cannon and the resulting death of five men of national prominence, actually stimulated ordnance innovators of the Civil War era to improve cannon technology.⁽⁶⁾ From 1845 interest had been expressed in larger guns, better shells, rifling, breech loading, and encasement in revolving turrets.⁽⁷⁾ These diverse research efforts saw the development of perhaps the best smooth-bore cannon of the time, the Dahlgren Cannon. Equally, turret development by Theodore Timby in 1843, and Captain Cowper Coles in 1859, immediately gained limited recognition from American naval officials.⁽⁸⁾

These developments occurred over the twenty years prior to the Civil War, often in isolation. By the beginning of the War, therefore, innovations had contributed very little to the standard of the USN, the general assessment being that at the beginning of the American Civil War, the navy was "obsolete, decayed and moribund."⁽⁹⁾

3.1

The Monitor

The Monitor class of vessels has been extolled as the single most important innovation in military technology during the Civil War.⁽¹⁰⁾ (See Appendix 8) One must, however, express reservations about this view. The USN Monitor should not be considered as a successful experiment, but rather as a design crowning the new epoch in naval technology.⁽¹¹⁾

4. Potter & Nimitz, Sea Power (1960:237-238)

5. L.E. Pearson, "The 'Princeton' and the 'Peacemaker': A Study in Nineteenth-Century Naval Research and Development Procedures", Technology & Culture (Vol.7[2], Spring 1966:163)

6. IBID:182-3

7. Potter & Nimitz, Sea Power (1960:240); & A. Hunter-Dupree, Science in the Federal Government (Massachusetts, Harvard University Press, 1957:123)

8. Potter & Nimitz, Sea Power (1960:242)

9. Anderson, By Sea & By River (1962:6)

10. Douglas Comments on Dupree in Gilchrist & Lewis, Economic Changes in the Civil War Era (1965:131); & McBride, Civil War Ironclads (1962:1)

11. Wolseley (Viscount), "An English View of the Civil War", North American Review (Part II) (Vol.149[392], July 1889:30-43)

While rich in its use of new ideas, the Monitor design built on existing technical knowledge. Although not a revolutionary 'breakthrough', the Monitor did mark the end of unsystematic, unplanned attempts to strengthen wooden ships with iron plates. Unlike all armoured vessels before it, the Monitor was from bottom up, the first purposely designed ironclad ever launched.

However, the Monitor was preceded into service by Confederate ironclads. The first ironclad of the Civil War was the ram CSS Manassas: which was essentially the hull of the tug-boat Enoch Train with an armoured superstructure.(12) The practice of converting pre-existing wooden ships to ironclads was pursued with the construction of the CSS Virginia using the hull of the ex-USS Merrimac, captured at Norfolk Harbour.

All the features of future ironclads were experimented with in the construction of the Virginia. The Merrimac had been burnt down to sea level, so that the upper deck structure had to be replaced. Therefore, it was purposely reconstructed with thick wood placed at a 50 degree angle. Onto this frame were bolted railway iron runners and crude iron plates, that took the armour band to some five inches thick.(13) Within this armoured casement, which could deflect all known cannon shot (including that fired by the 110-Pound Armstrong or Whitworth guns), were mounted eight seven-inch guns and two rifled guns in both the bow and stern.(14)

In the development of ironclad technology, it is clear that the South had an advantage, that was only to be matched by the Monitor and finally surpassed in 1863 when the North's superior metal-working factories swung into production.(15)

With the South's development of ironclad technology and its potential to produce a radical innovative breakthrough,(16) the North feared that the blockade by wooden ships spread over large tracts of coast could be seriously compromised. A Naval Board was instituted by Gideon Welles (the Union Secretary of the Navy) on 4 July 1861, to study the feasibility of ironclad construction. Not surprisingly, on 3 August 1861 the Board recommended the immediate construction of a shallow-draught ironclad capable of countering the Confederate designs.(17)

The first two designs accepted by the North were for the ironclads New Ironsides and the smaller Galena. However, the immediate threat posed by Virginia, coupled with the

12. J. Coggins, Arms & Equipment of the Civil War (New York, Double Day, 1962:133)

13. United Service Magazine, Naval & Military Journal, "Merrimac Conversion" (Part I, No.402, March 1862:97)

14. IBID

15. Potter & Nimitz, Sea Power (1960:263)

16. N. Reingold, "Science in the Civil War: The Permanent Commission of the Navy Department", Isis (Vol.49[3], No.157, September 1958:307)

17. McBride, Civil War Ironclads (1962:8 & 11)

lack of mobilised production resources, forced the late design entry of John Ericsson's Monitor to the forefront, as the technical design most capable of meeting naval requirements in the shortest period of time.(18)

The Navy Department had outlined a number of tasks that an ironclad must be able to do. They required a vessel that could support existing coastal and harbour defences, engage unfortified enemy harbour guns, and have a draught shallow enough to enable it to blockade rivers and enemy harbours.(19)

The actual design of the Monitor was never fully prepared and as its construction progressed rapidly, it really emerged directly from John Ericsson.(20) Still, the final weapons system to emerge was not only based upon past practical research, but made in fulfilment of naval requirements. Yet the Monitor was constructed as a totally new design, with only the use of the turret being acknowledged by the ship's builders (if not John Ericsson) as coming from a past patent.(21)(See Appendix 9) The first engineer on the Monitor stated that there existed at least forty patentable innovations on the vessel.(22)

The end design included many model features: including a low freeboard with a hull that had little reserve buoyancy, thus preserving a very low water-line profile to rams and shells. It mounted two eleven-inch Dahlgren smooth-bores (although it was intended to have larger cannons had they been available), encased side-by-side in a 360-degree revolving turret armoured with iron-plate and iron railroad tracks. The decks were made of oak plated with four-and-a-half-inches of armour that overhung both at the stern (to protect the screw and rudder) and at the prow (to protect the anchors). Finally, the design incorporated a double trunk steam engine, with thirty-six cylinders bored into a single casting, and two return box boilers that united to drive two screw propellers.(23)

The Monitor upon launching, represented the first purposely designed and built warship that incorporated iron armour and turret-mounted heavy ordnance, and also was steam-propelled and screw driven.

The Monitor, despite its novel configuration, was constructed in about one hundred days from the keel being laid on 25 October 1861 to its launch on 30 January 1862.(24)

18. Anderson, By Sea & By River (1962:67)

19. For Naval Policy in the North see, McBride, Civil War Ironclads (1962:12)

20. C.W. MacCord, "Ericsson & His Monitor", North American Review (Vol.149[395], December 1889:461-465)

21. Timby 1843 patent, McBride, Civil War Ironclads (1962:14)

22. IBID:14

23. IBID:16-17; & Potter & Nimitz, Sea Power (1960:266)

24. Anderson, By Sea & By River (1962:70)

From its inception, the vessel had been tagged by sceptics as "Ericsson's folly", yet by the conclusion of its historic conflict with the Virginia on 9 March 1862, it was recognized as the most significant alteration to naval technology since a "cannon fired by gun powder had been mounted on ships about four hundred years before." (25) This remarkable progression was achieved despite the failure to extensively test and redesign the Monitor between its completion on 15 February and its confrontation at Hampton Roads on 9 March 1862.

In fact it was left up to later Monitor class designs to overcome problems with poor speed, engine unreliability, waterproofing, shell- and shock-proofing (against splinters that ricocheted around the interior after hits in combat), the failure of its cannon to inflict damage on similar armoured vessels, and the total lack of stability in open waters that almost saw the Monitor sink whilst being towed to Hampton Roads. (26)

The dramatic test of the Monitor was to be the meeting between her and the Virginia at Hampton Roads. (27) The Hampton Roads confrontation confirmed the ironclad warship's tactical significance. The Virginia's sinking of the wooden front-line Northern ship Congress, the ramming and sinking of the Cumberland, and the grounding of the Minnesota all confirmed the superiority of ironclad vessels against wooden-hulled, wind-powered vessels. But on the next day, 9 March, the confrontation between the newly arrived Monitor and the Virginia, truly sounded the death knell of wooden vessels. (28)

The smaller Monitor withstood superior firepower and ramming, to negate the Virginia's victories of the previous day and produced a tactical stalemate that held the blockade. The euphoria of the discovery that one little ironclad could achieve so much made the possession of more iron-plated naval vessels not just desirable to the North, but also to the rest of the world. (29) Suddenly, a new impetus had been added to Northern innovation in ironclad technology. (30)

The Monitor represents the start of a new epoch in the development of armoured naval vessels. The vessel gave rise to innumerable design variations that used it as a basis,

25. W.S. Churchill, The American Civil War (London, Cassell, 1958:56)

26. United Service Magazine, "Merrimac Conversion" (1862:100); And not all solved by later design see problems suffered at Mobile Bay in F.A. Parker (USN-Commodore), The Battle of Mobile Bay (Boston, A. Williams, 1878:66)

27. B. Catton, The American Heritage Short History of the Civil War (New York, Laurel-Leaf Library, 1972:78)

28. D.D. Porter, "Naval Wars of the Future", North American Review (Vol.148[387], January 1889:13)

29. The Times (March 11, 1862:9) in H. Brogan (ed), The American Civil War: Extracts from The Times 1860-1865 (London, Times Books, 1975:69)

30. Baron De Stoeckl, Quoted in B.B. Sideman (ed), Europe Looks at the Civil War (New York, Onion Press, 1960:193)

while its success also provided the catalyst for purpose-built ironclad designs in both the North and the South. Rear Admiral L M Goldsborough, in a letter to the Federal Naval Secretary, Gideon Welles, believed development based around the Monitor design:

...afforded us the advantage of profiting by wholesome teachings. Experience is a great source of wisdom, and to be enabled to recede from error is a means of advancing the truth.(31)

So it was that the Monitor provided the technological model upon which further innovation occurred throughout the war. By the end of the war the North had manufactured over seventy-one ironclads, and by the end of 1864, five hundred and fifty-nine out of 671 front-line naval vessels, were propelled by steam.(32)

The design of the Monitor was also to influence shallow draught naval vessels and was to persist in service until the second decade of the twentieth century.(33) The Monitor was, therefore, a harbinger of new naval technology that built upon existing technical knowledge and confirmed the superiority of steam-propelled armoured warship designs over wooden vessels. She then laid the path for later technical developments to consider.

3.2 Torpedoes and Related Weapons Systems

Development of the torpedo during the Civil War stands as one of the most important examples of how wartime innovation took a technical entity, with a limited history of practical use, and refined it into a recognized component of warfare. Without doubt the advancements in torpedoes and their related weapons were one of the most underrated fields of technical change, to occur in the Civil War.

The torpedo was not a new concept. Inventor David Bushnell (1742-1826) is credited with designing a naval torpedo or sea mine at the end of the eighteenth century. Bushnell was subsequently responsible for the use of torpedoes to defend American ports from the English in the American War of Independence.(34) The use of torpedoes in warfare extended to the international arena with another American, Robert Fulton's attempts to sell his designs to the French. Further refinement of the torpedo also

31. Quoted in McBride, Civil War Ironclads (1962:157)

32. Brogan, The American Civil War (1975:156)

33. Purnells Illustrated Encyclopedia of Modern Weapons & Warfare (Vol. I) (London, Purnells, 1976:109-110); The Amphirite Class were laid down in 1863 and were scrapped between 1915 and 1920.)

34. J.S. Barnes, Submarine Warfare, Offensive & Defensive (New York, Van Nostrand, 1869:17)

Other cruder methods were devised for detonating torpedoes, including snag or trip wires, stretched across rivers. Once a boat connected with the lines, the torpedoes was pulled onto the vessel and detonated on impact.

The most reliable system for mounting torpedoes became the 'Keg' and 'Singer' torpedoes. These were simply moored below the water-line at shallow parts of a waterway. Because of the improved reliability of their detonator caps and waterproofing, these torpedoes were more successful than earlier designs.(39) (See Appendix 10) The design of Keg and Singer torpedoes represented an improvement on the designs from the early years of the war. They were able to stay in the water longer and had improved means of detonation that surpassed the older percussion caps, which were unreliable and volatile. They were also able to hold larger, waterproofed black powder bursting charges. Technical innovations in torpedo design were, however, not just restricted to its application in the water.

The Confederates' development of torpedo technology also produced extensions of its use in land warfare. Development that had produced torpedoes for a water-based environment shifted to apply new torpedo technology to the land. One interesting hybrid design was the 'coal torpedo', which was a bomb shaped as a piece of coal and placed in a ship's coal bin. This device was responsible for sinking the Union Greyhound transporter in 1864.(40)

Another innovation was the 'clock torpedo', literally a time bomb. It was extremely successful when used at City Point against the staging point for the North's advance against the South. Confederate Captain John Maxwell planted a box containing a clock torpedo on a Northern munitions tender supplying City Point. When it exploded it killed at least 58 people, wounded 126, and caused damage estimated at over four million dollars.(41) (see Appendix 13) Torpedoes of a similar design were also used by guerrilla raiders to destroy rail links. Placed on bridges or under railroad lines, these rudimentary bombs had very destructive capabilities.

The North's use of land torpedoes was less innovative. In June 1864 the Petersburg mine assault ushered in an effective use of the 'mine' in the ancient concept of sapping under an enemy's defences. It was here that the 48th Pennsylvania Infantry Regiment, in 38 days, built a shaft under a Confederate artillery position and then electrically detonated 8,000 pounds of black powder, arranged into a single explosive device.(42)

39. Coggins, Arms & Equipment (1962:146-147)

40. IBID:146

41. Perry, Infernal Machines (1985:132-134)

42. Willmott & Pimlott, Strategy & Tactics of War (1979:88); & W.H. Powell, "The Tragedy of the Crater", The Century Magazine, (Vol.34[3-62], July 1887:760-773)

The explosion left a 30-foot-deep crater 170 feet by 80 feet, plus 278 Confederate casualties. However, this Northern success was not typical of its exploitation of torpedo technology. It was mostly left to the South to use what the North considered "ineffectual and unlawful warfare" (43) in armed conflict.

The Confederacy, with its more innovative and ingenious design outlook, promoted the development of the anti-personnel land torpedo. The major development in land mines came with General G J Raines' creation of a pressure-activated fuse that could be mounted in artillery projectiles and then buried just below the earth's surface. These technical innovations resulted in subsequent field conversions of artillery projectiles. These were deployed in defensive entanglements to enhanced the defensive positions, such as Fort Wagner,(44) or were used as 'booby traps' in vacated positions.(45) These torpedoes came in all sizes and, as with their naval counterparts, were detonated by impact, lanyard, or trip wire.

The cumulative effect of these numerous technical changes to the torpedo and its modified variants, was to confirm it as a cheap, easy to produce weapon, that with little training for its users, could prove an ideal defensive weapon.(46)

It is apparent that the Confederate forces, whilst achieving some tactical and technical advantages in torpedo use, still lacked the resources to develop the technology fully or to concentrate these resources on the torpedo with the most technical merit. The failure to evolve torpedo technology through the most effective designs and overcome many initial design shortcomings, was to reduce the overall effectiveness of both the North's and the South's weapons.

The greatest ironclad of the war, the New Ironsides, twice survived torpedo attacks. On the first occasion an electrically fired mine over which she was stationary failed to explode because there had been a break in the firing line which severed the link with the operator on land.(47) The second occasion was in 1863 when she survived a successful David class torpedo boat's assault because its spar torpedo held too small a charge.(48) War records exist of numerous other failures to sink vessels because torpedoes either failed to detonate, were easily spotted, or suffered mechanical failures.

Nevertheless the torpedo still scored significant successes, two of which stand out. The first ever successful use of any torpedo to sink a warship occurred when the

43. U.S. Navy in Perry, Infernal Machines (1985:5)

44. IBID:59

45. IBID:224

46. C. Chant, How Weapons Work (London, Marshall Cavendish, 1980:224)

47. Perry, Infernal Machines (1985:52)

48. IBID:8

Confederates sank the USS Cairo at the end of 1862. Later the evolution in sea mines was highlighted by the sinking of the USS Jones with an electrically fired torpedo that was part of a submarine battery that had been in the water for twenty two months.(49) To further promote these successes, the Confederate navy encouraged any innovation that could better use torpedoes against Federal ships.

The use of torpedoes on vessels was mostly restricted to the use of windlass-mounted spar torpedoes. The first successful "torpedo boat" was the Confederate David class of craft. Developed by the South at Charleston, the vessel was a semi-submerged ironclad boat, with a steam engine driving a propeller.(50) Lacking the resources and means to build conventional motor gun launches, the Confederacy developed the David as a means of delivering torpedoes at Northern vessels. It was the South's only hope of breaking the Northern blockade. The fifty-foot vessel mounted a one hundred-pound torpedo on a forward slung windlass spar and quickly proved its effectiveness against an unprepared enemy by torpedoing the ironclad New Ironside. However, the David failed to sink the ironclad because the spar torpedo had only a sixty-pound charge mounted.

Described by the head of the Federal Navy, Admiral Dahlgren, at its first trial as the best achievement of any invention,(51) the David inspired a whole new class of naval torpedo boats. It was followed in mid-1864 by the Confederacy's Squib, which used ideas of the designer of the David, F D Lee. The North also achieved success in the field by using a steam launch, commanded by Lieutenant W B Cushing, to deliver a spar torpedo that sank the CSS Albemarle. However, Northern industrial superiority was able to produce the most formidable torpedo boat, when it launched the Spuyten Duyvil which operated on the James River from late 1864 to 1865 and mounted not only eight torpedoes but also two clock torpedo explosives.(52) (See Appendix 15)

The success of the David and the desperate situation of Charleston also provided the spur that encouraged other unconventional, alternative designs capable of acting as torpedo delivery vehicles. The most notable of these vehicles, was the submarine.

The basis for American submarine technical knowledge was established by the endeavours of Robert Fulton. Fulton was a world leader in submarine technology prior

49. IBID:112

50. Barnes, Submarine Warfare (1869:43); & McBride, Civil War Ironclads (1962:108-109)

51. Perry, Infernal Machines (1985:83)

52. C.G. Reynolds, "Yankee Supership? Sortie of Spuyten Duyvil", American Neptune (Vol.42[2], 1982:85-100); Perry, Infernal Machines (1985:142); Barnes, Submarine Warfare (1869:155, Plate xiii); & Official Records of Union & Confederate Navies in the War of Rebellion (Series i, Vol.12) (Washington DC, Government Printing Office, 1901:94)

to the war (53) and his experiments formed the basis for work on the first submarine to be launched in the Civil War, the CSS Pioneer.

However, this vessel had a limited deployment and was sunk or scuttled in New Orleans on 31 March 1862.(54) The Pioneer served to inspire the Union into designing their Alligator, and provide the basis for the USS Intelligent Whale submarine. In spite of these early designs efforts, none were effectively deployed during the Civil War and the North never succeeded in deploying a battle-worthy design.(55)

After previous problems with wartime submarines, the CSS Hunley became the unlikely design to be the first deployed against the enemy. As with the CSS Pioneer, this design was also directly based around an earlier design by Fulton.(56) But the Hunley was a crude construction built around an old boiler. It suffered innumerable design faults, not least of which was the lack of an electric motor, which meant it had to be driven by eight men manning a hand-cranked propeller. After sinking three times in accidents and submerging trials (killing all the crew), Hunley was still deployed like a David in a semi-submerged state. In an engagement on 17 February 1864, Hunley sank the USS Housatonic. She then immediately followed her victim and took her brave crew to their deaths.

What torpedo boats and the submarine did stimulate was the consideration of the torpedo's offensive rather than just defensive capacities.

While the North did try to develop a submarine (57) they had more success with other delivery vehicles, and the development of innovations to counter the threat posed by torpedoes. John Ericsson's obstruction remover, false prows, large wooden river bed drag frames, floating nets, and armoured ship bottoms, were all evolved to counter mines.(58) Attempts to counter the threat of torpedo boats produced such innovations as powerful searchlights with magnifying mirrors, defensive nets and obstructions, rapid-firing machine guns mounted on patrol boats, and fast light vessels intended for destroying torpedo boats.

Other naval uses for torpedo technology were also explored. Although research had been done on self-propelled locomotive torpedoes by Luppis and Whitehead in

53. E.T. Parkes, "Robert Fulton & Submarine Warfare", Military Affairs (Vol.25[4], Winter 1961-62:177-182)

54. N. Polmar, The American Submarine (London, Patrick Stevens, 1981:7)

55. IBID:9

56. R.F. Burgess, Ships Beneath the Sea (New York, McGraw-Hill, 1975:69)

57. This includes the Intelligent Whale and designs that never quite overcame the technical problems with propulsion and steering. See Civil War Naval Chronology 1861-1865 (Index) (Washington DC, Naval Department, c.1965:366)

58. Barnes, Submarine Warfare (1869:86-87)

Europe,(59) their American contemporaries knew little of their work. The work of American innovators Major E B Hunt and John Ericsson, on a submarine self-propelled torpedo or shell, never resolved the problems of guidance and waterproofing that the Whitehead torpedo later managed to overcome.(60) Work on submarine bombs, or what today would be called depth charges, was also terminated due to a lack of perceived need for such a weapon.(61)

In essence, the torpedo forced technical innovation that saw mine designs advance and promote ancillary developments in torpedo boats, submarines, and counter naval vessels such as torpedo boat destroyers and mine-sweepers.

The importance of the torpedo in the war is clouded by two points. The torpedo did not change the outcome of a major battle,(62) nor could it be said to have significantly influenced the course of the war. But with four monitors and twenty seven other victims sunk, the torpedo did achieve greater success than any other weapon in sinking Federal ships. The North was also able to sink or severely damage seven Confederate ships with torpedoes.(63) In addition, the fear induced by the "torpedo phantom" (64) provided an unquantifiable deterrent to Northern naval commanders' otherwise unchallenged passage through coastal and river waters.

The evidence of torpedo innovation during the Civil War suggests that torpedo technology did not reach a single design that may represent an apex in torpedo technology.

In a comment on Civil War torpedoes, the Prussian observer Victor Ernest Rudolph von Sheliha made the incisive comment that:

The great error which a host of inventors fell in was, that they aimed at accomplishing, all at once, too much in a field which to all of them ... was still an unexplored terra incognita.[sic] Complicatedness of the apparatus was the next consequence ... which resulted in its utter failure in being tried.(65)

The development of torpedo technology, therefore, was far from a complete success. Yet application of the technology on the battlefields (land and sea) hastened practical research into torpedo technology. Unlike other Confederate naval innovations that had been tragically frustrated, the submerged torpedo and torpedo delivery systems

59. Chant, How Weapons Work (1980:224)

60. Barnes, Submarine Warfare (1869:193-198)

61. IBID

62. Perry, Infernal Machines (1985:196)

63. Coggins, Arms & Equipment (1962:146); & Perry, Infernal Machines (1985:4)

64. Fulton quoted in Perry, Infernal Machines (1985:52)

65. Quote in IBID:29

underwent extensive technical development (66) and a Torpedo Corps was established specifically to promote its effective use.

Combined with the North's recognition of the torpedo as a means of blocking harbours or of arming small, fast, steam launches, the torpedo can be seen to have developed into a valuable weapon with a demonstrated capability that was to produce a lasting influence on naval tactics.

66. Anderson, By Sea & By River (1962:298)

CHAPTER 4:

GENERAL INNOVATIONS

4.1

Artillery

Technical innovation in artillery was pursued by both the North and the South, and by both the armed services and private individuals. These technical endeavours were to make the American Civil War the highest point in muzzle loading, smooth-bore technology. As well as being the last war in which smooth-bore pieces predominated, it was also the first war where rifled ordnance was extensively used.(1) As this suggests, artillery became the subject of intensive technical development during the Civil War.(2)(See Appendix 17 & 18)

In the North, innovations in artillery never replaced the standard smooth-bore technology. In the South, increased demand coupled with a small industrial base, forced heavy reliance on captured weapons and on whatever imported rifled and breech-loading modern artillery pieces the Confederates could secure. Despite their relying on such weapons, the Confederacy's Tredegar Iron Works at Richmond, from 1863 to 1865, manufactured 3,000 cannons, the bulk of which were smooth-bores.(3)

Thus, unlike Northern advances in rifled artillery which were always stilted by the voluntary adherence to smooth-bores, the Confederacy, despite making use of breech-loaders such as the Whitworth, Blakely and Armstrong pieces, remained dependant on smooth-bores.(4) Adherence to smooth-bores was further enforced by the Confederacy's inability to produce reliable fuses and high explosive shells for breech-loading artillery.(5)

The North's industrial capacity enabled Federal forces to develop large-bore artillery pieces, and also provided facilities for high-grade iron manufacture that benefited railroad line and warship construction.(6) At sea, the continuing development of large calibre guns produced notable innovations. The pre-war development of the Rodman and Dahlgren smooth-bores and their manufacturing techniques,(7) led the Naval

1. I.V. Hogg & J. Batchelor, A History of Artillery (London, Hamlyn, 1974:61)

2. B.R. Lewis, Notes on Ammunition of the American Civil War 1861-1865 (Washington, American Ordnance Association, 1959:13)

3. J.M. McPherson, Ordeal By Fire: The Civil War & Reconstruction (New York, Alfred A. Knopf, 1982:192)

4. Lewis, Notes on Ammunition of the American Civil War 1861-1865 (1959:13)

5. McPherson, Ordeal By Fire (1982:192)

6. J.F.C. Fuller, Armament & History (London, Eyre & Spottiswoode, 1946:123-124)

7. E.B. Potter & C.W. Nimitz (eds), Sea Power: A Naval History (New Jersey, Prentice-Hall, 1960:240)

Department and prominent technologists to believe that the perfect gun had been produced.(8) Two fundamental misjudgements resulted from this belief.

Firstly, the inability of smooth-bores to destroy armoured ships (despite their effectiveness against wooden vessels), led to the extensive use of ironclad rams. Contemporary military thought held that ramming was a key naval tactic.(See Appendix 25) This in turn led to smooth-bores being developed to shatter armour at close ranges. High-velocity rifled artillery that could penetrate armour was virtually ignored in America.(9) Secondly, the concentration on smooth-bores discouraged the development of superior gunnery skills by improved gun laying and sighting. Concentration was placed on close-quarters engagements with the sole aim of ramming an opponent.

At sea and subsequently on land, rifled ordnance and particularly improved breech-loading systems, were never extensively improved. Lack of official interest in their adoption curtailed innovative attempts to overcome problems with jamming of mechanisms, gas escape, and lack of design strength in key components.(10) At sea, rifled breech-loading systems were not to replace smooth-bore muzzle-loaders until the 1880s.

On land, armies also clung to smooth-bore weapons. Muzzle-loaders, in particular the 12-, 24- and 32-Pounder howitzers, and the 12-Pounder "Napoleon" field gun, formed the core of both sides' field batteries.(See Appendix 16) In the North, Napoleons constituted at least two thirds of artillery pieces used in land engagements. It was only in the battle at Gettysburg that Napoleons did not constitute at least half the field pieces deployed.(11)

The success of the smooth-bore 12-Pounder was achieved despite the existence of the good 12-Pounder James rifled gun. This weapon weighed less than the smooth-bore 12-Pounders and due to less windage (the difference between the diameter of the shot and bore) had greater range and better accuracy.(12) However, the Napoleon was well liked for both its reliability and its efficiency when countering close range targets.(13) Even in the South, which chose to build the Napoleon from 1861 to 1864, General Lee

8. A. Hunter-Dupree, Science in the Federal Government (Massachusetts, Harvard University Press, 1957:123-124)

9. United Service Magazine, Naval & Military Journal, "Defects of Armour Plating" (Part I, No.399, February 1862:189)

10. W.H. McNeill, The Pursuit of Power (Oxford, Basil Blackwell, 1983:239)

11. J. Coggins, Arms & Equipment of the Civil War (New York, Double Day, 1962:64)

12. IBID:70

13. F.D. Downey, The Guns at Gettysburg (New York, Collier Books, 1962:155 & 171-3); & L. Naisawald, Grape & Canister (New York, Oxford University Press, 1960:20-21)

felt its simplicity and its performance at short range in wooded country, made it the piece around which the Southern artillery should be built.(14)

Technical innovations in artillery pieces, such as improved weapons like the rifled 3-Inch Ordnance, the 3-Inch Parrott, and the 20-Pounder Parrot, never systematically replaced smooth-bores in the North.

Interestingly, the North's reliance on Robert Parrott's 10-, 20- and 30-Pounder rifled cannons, may well have been due mainly to their simple design rather than there being any technical advancement. The main advantages being that they were quick and cheap to produce while still being relatively robust weapons. Parrott himself commented that although they were not the most perfect of designs, they were the most practical available.(15)

The South's lack of resources restricted attempts to experiment with rifled or other innovative artillery types. Official support for the introduction of new designs was muted by fears that technical innovation in ordnance matters could waste scarce resources. Thus whilst breech-loaders were imported from England by both sides (mainly Armstrong, Blakely, and Whitworth guns), the problem of machining two barrel sections and a breech mechanism, the need for constant field cleaning, the cost of manufacture, and the lack of breech-loading ammunition, all combined to temper indigenous technical development.(16) The necessity for field artillery pieces to be horse-drawn also severely restricted the popularity of heavy breech-loading and large calibre rifled ordnance.

Lack of technical development was not the only cause for the dearth in further artillery designs. The strain weapons would place on existing manufacturing resource was certainly a major consideration. One of the reasons for the Napoleon's popularity was that it fired cheap, easy to use, muzzle-loading ammunition. The South's reluctance to develop rifled ordnance and its reliance on the 12-Pounder smooth-bore was due in no small part to its inability to produce reliable percussion fuses and to manufacture technically advanced shells.(17)

Developments in artillery ammunition mostly meant manufacturing shells that could easily be loaded into the muzzle of a rifled cannon but expand (to reduce windage) into

14. Coggins, Arms & Equipment (1962:64)

15. W. Ripley, Artillery & Ammunition of the Civil War (New York, Van Nostrand Reinhold, 1970:110)

16. Hogg & Batchelor, A History of Artillery (1974:56, 64 & 66)

17. J. Gorgas, Ordnance Manual 1863 in C.E. Fuller & R.D. Steuart, Firearms of the Confederacy (West Virginia, Standard, 1944:130)

the grooves on firing. Such innovations gave high priority to the development of new and more reliable fuse types.(See Appendix 12)

Some major factors inhibited innovations in shell technology. The most significant of these was the North's failure to develop breech-loaders. Newly developed shells that could be muzzle-loaded but which expanded on firing became obsolete as breech-loaders gained greater international recognition. This was despite numerous innovations such as lead casings, expanding rings, discarding sabots, raised studs, and grooves or belts, that tried to improve muzzle-loading rifled artillery.(18)(See Appendix 17) These shells never fully overcame the problems of fouling and wear caused by firing shells that expanded into ML cannon's rifling.

Developments in shrapnel or spherical case shots by the end of the war, removed the smooth-bores' remaining advantage: their superiority over rifled pieces in dealing with massed targets at close ranges. The Napoleon and its effective canister round were, however, still used throughout the war. Despite this, developments in ammunition continued as fast as innovators could devise new ways to use fuses, or could marry new fuse technology to potentially effective shell designs.

The development of fairly reliable fuses overcame most limitations on new shell designs. Fuses were designed that could be detonated by percussion, concussion, time, or a combination of types.(19) The explosive shell or case type of shell, in its myriad of designs, was mostly set off by a powder-train fuse that screwed into the face or nose of the projectile.(20) This fuse had replaced wooden or paper fuses made to burn and ignite the main black powder bursting charge at set times.

The first American innovation to dramatically alter fuse and shell technology was the Bormann (Boarmann or Borman) fuse. Despite working only about 75 per cent of the time, the fuse was the most widely used type by the North and South.(21) Whether fitted to smooth-bore shot or to rifled shells, the design's innovative features worked equally well. The fuse was a timing fuse with a punch type powder train design, that permitted the user to manually pierce the fuse at the required time delay; propellant gases released by the shell on firing would ignite the fuse.(22)

18. Naisawald, Grape & Canister (1960:546-547); & Downey, The Guns at Gettysburg (1962:211)

19. Downey, The Guns at Gettysburg (1962:209)

20. Naisawald, Grape & Canister (1960:542)

21. IBID:543; & Coggins, Arms & Equipment (1962:82)

22. F.W. Hackley, Report on Civil War Explosive Ordnance (Maryland, U.S. Naval Propellant Plant, 1960:31)

Percussion fuses, like the most common Hotchkiss type, had a plunger that was armed when a pin was released on firing.(23) The Schenkl combination fuse, used in the widely manufactured Schenkl projectile, had a percussion plunger that was activated prior to firing by removing a pin; it also had a timing device that was activated by rotating the fuse head.(24) A typical concussion fuse was the Tice concussion fuse; used on both smooth-bores and rifled-bore projectiles, it was armed by exposing a glass fulminate on its head, that shattered on impact, causing a flash that detonated the bursting charge.(25)

Many other types of fuses were designed. These included the US Water Cap Time, the updated Paper Time Fuse used by Confederates in conjunction with copper fuse adaptors, Confederate chemically fired pressure land mine fuses, Grenade Plunger fuses, and Mortar Wood fuses, as well as various design changes to basic fuses made by gunners in the field.(26) All fuses, regardless of type or design, suffered from two major failings. First, the manufacture of fuses was often crude, with the South in particular producing some very rough and unstable fuses. Second, manufacturing problems were compounded by the fact that most shells had to land directly on their noses to guarantee detonation. Time and concussion fuses were the only ones likely to detonate without direct pressure on the shell's nose, yet these were also the most unreliable type in use.

Improvements in ammunition did, however, enable rifled muzzle-loaders to end forever the strategic role of brick and mortar fortifications (27) and to improve the range, accuracy, and penetration of large coastal and siege cannons.(28)

Aside the design of guns, ammunition and fuses, there was one other important area of artillery innovation during the Civil War. In sight and fire control, large calibre artillery achieved a few limited advances. Gun mounts also went through some notable evolutions. These included mounting guns:

- * on rail flatcars;
- * on fully rotating turrets on naval vessels;
- * in protected barbettes for sea-coastal positions;
- * on boat carriages devised to allow a gun to be used on a boat or ashore;

23. IBID :33

24. IBID:40

25. IBID:42

26. IBID:i

27. Captain Justus Scheibert in J. Luvaas, The Military Legacy of the Civil War: The European Inheritance (Chicago, University of Chicago Press, 1959:67)

28. Coggins, Arms & Equipment (1962:86)

- * on experimental mounts using recoil buffers – recoil slides that sloped away and upwards from the point the barrel fired at; and
- * on other carriages that sought to either cut recoil or to give heavy guns all-round traverse.

One interesting development was associated with the introduction of the balloon. Whilst the balloon assisted artillery fire control, its proximity to the battery often attracted counter-fire from the opposing artillery. Thus many artillery pieces, particularly rifled pieces that fired time fused shells over long ranges, were used to fire at balloons.(29) Where positions were well-established these guns had their trailers placed into specially constructed holes that enabled their wheels to be locked in a static position whilst the normal elevation of the gun could still be employed for its original field artillery role.(30) In effect these ingenious adaptations to the guns' use produced the first purpose-designed anti-aircraft guns.

Technical development of the gun also occurred in areas where it had little impact on existing designs. The use of steel in guns and gun carriages, further metallurgical and design work on existing guns, experiments with electrically fired guns, steam compression weapons, and 'rocket guns', all failed to influence Civil War artillery.

Artillery development did not, in any technical area, dramatically alter the course of the war. Some developments certainly influenced the future of artillery and did alter the principal uses and characteristics of guns used in the war, but despite wide technical innovation, improvements were made mostly on existing design features. Alternative designs to muzzle-loading smooth-bores did not replace all smooth-bore weapons, and very little progress towards a single universally accepted, breech-loading, rifled weapons system was made.

4.2

Ordnance

A number of far-reaching military technological innovations do not easily fit into any one category and will be included under a general study of ordnance.

The discussion of Civil War technical ordnance would not be complete without at least an acknowledgement of innovations such as gun sights, hand grenades, rockets, flamethrowers, stink shells, and explosive rifle shells. These developments are often shrouded in mystery, and sometimes their actual use in the war has become a matter of

29. F.S. Haydon, Aeronautics in the Union & Confederate Armies (Vol.I) (Baltimore, A. Doctoral Dissertation, 1941:204); & Official Records, "The War of the Rebellion, A Compilation of the Official Records of the Union & Confederate Armies" (70 Vol.-127 Books) (Washington D.C., Government Printing Office, 1880-1901) (Series III, Vol.III, 1899:275)

30. Downey, The Guns at Gettysburg (1962:88)

some conjecture. But collective study of them may help to further build a picture of technical innovation during the war.

As the war progressed, a number of developments helped increase the accuracy of weapons. As well as innovations to small arms and artillery fire, the contributions of binoculars, telescopes, the telegraph and balloons must be credited with important roles. Gun sights also underwent certain technical development: graduated posts with ranges over 300 yards and up to 1000 yards were fitted to rifles,(31) replacing inadequate short range, L-shaped post rear sights, with two alternative settings.(32)

As weapons became more accurate, there followed a number of other innovations. A telescopic sight was fitted to snipers' rifles.(33) Front sights were designed that could be adjusted laterally to allow for windage (the space between the shell and the barrel rifling). Micrometer sight were also devised to permit adjustments for elevation and also for side winds over the chosen range.(34) The adoption and extensive use of better sights, and tubular barrel mounted telescopes, such as the highly efficient British designed Davidson Telescopic Sight, led not only to an improvement in sniping, but to an overall increase in the marksmen-soldiers' usefulness as a battlefield weapon.(35)

Artillery-sight development was equally interesting. With rifled weapons and weapons of large calibre, the use of indirect fire onto targets increased and 'over the horizon fire' became more common. In fact, as the war progressed, refinements to sighting made old line-of-sight (aiming down the barrel like a rifle) and graduated spirit levels, obsolete.(36)

With more scientific research into trajectory and ballistics, accuracy was worked out by range determined from barrel elevation, the point of aim or direction, and the drift all rifled cannon gave to shells.(37) Thus a consistent aiming point could be derived by selecting a prominent feature in the area. With this point and the gun's position established on a map, a few minutes' work would establish the aiming point, so that on firing, instead of having to re-lay the gun every time, the sight could just be reset to the aiming point already established.(38) For coastal guns, the gun itself was used as the fixed point, the sea as the horizontal range, and the gun's elevation as the height and

31. D.F. Butler, United States Firearms: The First Century, 1776-1875 (New York, Winchester Press, 1971:180)

32. IBID:180

33. Coggins, Arms & Equipment (1962:37)

34. Butler, United States Firearms (1971:171)

35. I. Skennerton, The British Sniper (London, Ken Trotman Arms Books, 1984:2-3)

36. Hogg & Batchelor, A History of Artillery (1974:111)

37. IBID:110

38. IBID:111

range of the shell. An equation could then produce a crude fix upon the target. Such range-finding techniques were also enhanced by pre-established ranges, which were mathematically recorded on complex range cards.

Whilst the evolution of sights relied upon the ingenuity of contemporary innovations and more scientific methods of use, the development of the hand-grenade could be traced back to bark, glass, and clay vessels filled with black powder that were used in the fourteenth century.(39) Yet the Civil War directed this development into new areas.

The most widely used of all types of hand-grenade was the Northern Model 1861 Ketchum grenade. This weapon had a dart shaped body with a fitted impact detonator plunger, with a fitted wood and cardboard, winged tail assembly.(40) (See Appendix 12) The other types of grenade used by both sides in the war, were smooth-bore projectiles converted for use as grenades. The United States Adams Grenade was one such grenade used by the North. It had a pull, friction ignited fuse that was usually fitted to a 6-Pounder shot.(41)

Figure 4 Grenade Supply Figures US Army 1861-65

Type of Hand-Grenade Purchased	Total Cost \$	Total Units
1-Pound Ketchum	25,556	15,576
3-Pound Ketchum	42,799	34,340
5-Pound Ketchum	24,845	22,815
Adams Hand-Grenade	5,000	4,750

Some hand-grenade innovations did not attain the technical level of the Ketchum and Adams designs. The US Hanes (otherwise called Haynes or Excelsior) Grenade was more dangerous for its users than for the enemy. Built with a spherical case surrounding an inner spherical charge that was fitted with detonator caps, the whole grenade had no safety mechanism except for extreme care.(42)

Other grenades were used with varying degrees of success. In particular, work around the torpedo design produced some hand thrown time bombs. Confederate forces are recorded as having thought highly of the grenade as a defensive weapon. The South is

39. C. Chant, *How Weapons Work* (London, Marshall Cavendish, 1980:221-222)

40. Luvaas, *The Military Legacy of the Civil War* (1959:40); & Hackley, *Civil War Explosive Ordnance* (1960:28)

41. Hackley, *Civil War Explosive Ordnance* (1960:28)

42. IBID:27

known to have issued grenades to some coastal forts thought likely to face mass assaults by Northern forces.(43)

Research and development in explosive weapons also produced extensive experimentation with rockets. From the time of the attack on Fort Sumter to the very end of the Civil War, rocket weapons were used in varying roles and with different degrees of success.(44) The oldest of all explosively propelled projectiles, the rocket had seen practical use in the late eighteen and early nineteenth centuries. Colonel Sir William Congreve's war rocket was used by both the army and navy. However, neither he nor the rocket development that followed through the nineteenth century till the end of the Civil War ever produced a rocket that had significant tactical impact on military engagements.(45)

In the early stages of the war the rocket appeared to hold as much potential for military use as any other technical innovation. With President Lincoln's encouragement, experimentation continued – although his own life had almost been lost at a rocket testing when the missile exploded on take-off.(46) Experiments with technical innovations in rockets were to have similar success. Attempts to devise a rocket-propelled torpedo for use on Northern naval vessels had a most unfortunate practical test. Without any means of steering the missile and little real knowledge of flight stabilisation, the inventors of this first sea-to-sea missile managed to miss the large target ship completely with the first shot and on the second firing, to sink a vessel. Unfortunately, it failed to sink the target vessel and instead sunk another moored nearby.(47)

Rockets were, however, developed to a point where they could be used by both the North and the South in a variety of roles. Unlike other innovative weapons like the machine-gun and the flamethrower (where faults in the original technical innovation inhibited official interest), the rocket was still seen to have some military usefulness. Unlike the flamethrower (where little is known about its innovative features or actual use)(48) the rocket was known to have been used for signals,(49) as an offensive

43. Records of supply to Fort Morgan and Fort Gains at Mobile Bay. See F.A. Parker (USN-Commodore), The Battle of Mobile Bay (Boston, A. Williams, 1878:125)

44. Coggins, Arms & Equipment (1962:107); & P.D. Olejar (Major), "Rockets in Early American Wars", Military Affairs (Vol.10, 1946:33-34)

45. J.F.C. Fuller, The Decisive Battles of the Western Worlds (Vol.III) "From the American Civil War to the End of the Second World War" (London, Eyre & Spottiswoode, 1956:3 & 89; & Olejar, "Rockets in Early American Wars" (1946:33)

46. R.V. Bruce, Lincoln & the Tools of War (Connecticut, Greenwood Press, 1973:ix & 219-220)

47. IBID:178

48. IBID

49. Scheips in W.R. Plum, The Military Telegraph: During the Civil War in the United States (Vol.I & II) (New York, Arno Press, 1974:Introduction)

incendiary naval device and siege weapon (mostly signal rockets turned onto targets), and as a 'star' or illumination device to light up night skies and allow the navy to spot blockade runners, who mostly ran the gauntlet at night.(50) (See Appendix 19)

The use of illumination projectiles brings signal pistols into the study. Although crude in appearance, these pistols – the Model 1861, Model 1862 and a late war conversion of the Model 1862 to take a "star" instead of a flare projectile – were in fact the first effective signal pistols used in any war. They were single-shot front-loader designs, with hammers firing the projectiles by means of an attached percussion cap. They were used both on land and at sea, although it appears from the records that they were only produced by the North.

Two other explosive projectiles that were endowed with unique technical features and which are known to have been used in the Civil War, are the 'stink' shell and the explosive bullet.

Stink shells could not only be fired from rifled cannons but also could contain different substances, like poisonous gas or phosphorous.(51) These innovations were called "carcasses", smoke balls, suffocating balls, and stink or stun shells. The origin of wartime designs appears to be Oliver "Pet" Halsted and Alfred Birney's incendiary shells and Levi Short's tin canisters filled with Greek fire.(52)

The shells were used in two forms. The first type was designed by the North to be used for removing Confederate soldiers from dug-in defensive positions, where explosive shells could not penetrate. They seem to have been a mixture of chemical components used to produce gases that suffocated or produced such a stench as to force soldiers from defensive positions and make them easy targets for the opposing riflemen.(53)

The second form of shells had designs based on liquid fire. Records remain of their use at Charleston on 22 August 1863. General Beauregard, commander of the Confederate defences, noted the effect these shells had on the town. He stated that the shells were "the most destructive missiles ever used in war", causing destruction of military and civilian personnel alike.(54) General McClellan also saw the impact his shells could produce and categorically stated that "such means of destruction are hardly within the category of those recognized in civilized warfare."(55)

50. Coggins, Arms & Equipment (1962:153)

51. F.A. Shannon, The Organization & Administration of the Union Army (Vol.I) (Massachusetts, Peter Smith, 1965:142-143)

52. Bruce, Lincoln & the Tools of War (1973:237 & 243)

53. IBID:244

54. IBID:243

55. Official Records (Series III, Vol.I) (1899:606)

Another device that brought into question the users' adherence to the principles of civilized warfare was the explosive bullet. Despite the fact that after the war in 1868 the second Geneva Convention on war would ban explosive bullets,(56) both antagonists in the Civil war had conducted extensive experiments with them.(57)

Although neither side admitted using explosive bullets, evidence exists of each side accusing the other of using them, and medical records of wounded treated for horrific wounds, plus General Grant's condemnation of their use at Vicksburg, tends to confirm the wide use of explosive bullets by both the North and the South.(58)

The explosive bullet experiments seem not to have produced a bullet that could be provided in large numbers. However, it is known that 33,350 Gardiner Explosive Shells were made from 1863.(59) Made in 0.54, 0.58 and 0.69 calibres, the bullets had a cavity in the base where slow-burning powder was ignited on firing and exploded later. If already inside a victim, such a bullet would produce horrific injuries. Evidently the Gardiner Bullet was the only officially produced explosive shell to reach wide production.

Musket 'shells' exploded by percussion were recorded as having been used by Confederate forces,(60) while from the battlefield debris at Vicksburg it is apparent that the Confederates either captured Gardiner Bullets or had some other design which is yet to be discovered. More likely is that the Confederate forces were using explosive musket shells.

Personal accounts of Civil War soldiers, as well as discarded bullets uncovered on battlefields, have shown that the soldiers of both sides were not averse to re-shaping bullets on breech-loading cartridges. Either rounding off bullet noses or by notching bullets, soldiers produced projectiles that expanded on impact.

It should be noted, in fairness to the soldiers who reshaped bullets, that the musket ball with its low velocity and flattening effect after firing was a much more destructive missile than the newly designed breech-loading small arms projectiles of the 1860s.

Alongside the other changes to general ordnance technology, it is possible to see that technical innovations were not exclusively restricted to changes in weapons designs. In fact, innovative changes to weapons components or improvements in ancillary

56. Bruce, Lincoln & the Tools of War (1973:282)

57. Butler, United States Firearms (1971:58)

58. Bruce, Lincoln & the Tools of War (1973:282); & Peterson National Rifle Association of America, Civil War Small Arms, (Washington, NRAA, 1960:13)

59. Butler, United States Firearms (1971:59)

60. Peterson in NRAA, Civil War Small Arms (1960:13)

technology greatly affected the performance of some prominent military arms (eg. the railway, telegraph, or BLR small arms).

Although not always receiving academic attention, innovation in general ordnance did influence military technology. Some important advances made by innovations over pre-war technical knowledge, have often be lost in the general clutter of poorer technical designs.

TECHNICAL CHANGES SUMMARY

Past technical knowledge and contemporary design work seems to have paved the way for most Civil War innovations. Only in cases such as the development of ironclads, torpedo delivery vehicles, later repeating breech-loading small arms, and ammunition designs, may the intention to produce better weapons be seen to be prompted by a perceived military demand.

Over the length of the Civil War the scope of technical endeavour became consolidated around the efforts to develop a few novel weapons. Innovators seem to have strived to make technical advances that made their innovations stand apart from other competing designs. Yet these design improvement did not guarantee military acceptance. In fact many technically sound weapons did not reach a high level of design acceptance.

Innovations on breech-loading mechanisms, ammunition, more rapid firing weapons, naval construction, and torpedoes, produced fundamental advances upon technology existing prior to the Civil War. Other developments in telegraphy, balloons, railways, and ordnance designs, became more widely used but were built on technical knowledge in existence before the war. Even when introduced into service, many of the above innovations still failed to be fully adopted and subsequently their technical evolution floundered. This confirms the need for further investigation of non-technical reasons for a technology's failure to be fully developed. This will be done in the following Part II of this thesis.

Neither studying technological change alone, nor establishing that a great volume of innovation did occur, effectively explains how successful technical growth was, nor why certain innovations failed. Obviously more dimensions to innovation, other than just a comprehensive examination of individual technical advancements, need to be considered before a comprehensive picture of Civil War technological change may be arrived at.

PART II

ENVIRONMENTAL FACTORS

PART II

ENVIRONMENTAL FACTORS

INTRODUCTION

A comprehensive survey of technological change involves an examination of not only technical developments but also the influences on it from the environment. The environment here means the non-technical elements or societal influences that affected technology.

This definition enforces this study's acknowledgement that military technology interacts with the existing environmental system and cannot be understood just from an isolated survey of technical changes.(1) As no technical innovation can be said to occur divorced from environmental factors, the next two chapters will explore the general and specific environmental conditions. They will endeavour to identify those non-technical factors that were central to military technological change. The final chapter of this Part will round-off the examination of environmental factors by identifying how these non-technical factors affected the development of key innovations.

In effect, the study will follow G H Daniels' guiding statement that "... the direction in which society is going determines the nature of its technological innovations" and, therefore, no technological innovation, whether alone or in combination, "ever changed the direction in which society was going before the innovation."(2) As such, an innovation does not occur in isolation from the wider social context.

Such statements suggest that while technical entities are the key guides to technological change, they only result from a complex interaction between environmental factors, existing technology, and technical knowledge. Equally, no honest assessment of technological change could predict the direction of innovation, from solely an examination of the course in which society is developing.(3) The stimulus of technical change affects society and in turn the social structure is a determinant in the ability to apply technical knowledge.

During the course of the next three chapters, it will then be necessary, to establish the general environmental factors in the sphere of government, industry, and society, that had a primary role in influencing the course of Civil War military innovations.

1. S.B. Lundstedt & E.W. Colglazier (eds), Managing Innovation (New York, Pergamon Press, 1982:xiv)

2. G.H. Daniels, "The Big Questions in the History in American Technology", Technology & Culture (Vol.11[1], January 1970:3)

3. H. Rose & S. Rose, Science & Society (London, Pelican Books, 1970:240-245)

CHAPTER 5 : GENERAL ENVIRONMENTAL FACTORS

When Clausewitz linked war with the extension of a state's (nation's) will, he produced a form of thought that was to evolve into the twentieth century concept of "total war" or "absolute war".(4)

As a feature of twentieth century wars, total war moved from a loosely defined construct of Clausewitz, to explain the reality of total mobilization of soldiers, military capabilities, industrial capacity, economic might, and political will. This feature has become an important measure of modern wars as major twentieth century wars have involved the total commitment of all the latest means to ensure military goals were attained.

Thus while some may argue that even wars occurring hundreds of years ago may have attained features of total warfare, the linking of political will and industrial capacity to produce wars of mass destruction are distinctly modern. Wars prior to the modern era have then been labelled as "limited wars". While there is no single, adequate description of what a limited war actually entails, it has been used in juxtaposition with total warfare to highlight the different levels of commitment by the State.

An assessment of the general environment affecting Civil War technological change, with particular emphasis on the role of government, industry, and society, is intended to highlight how total was the commitment made to the war effort in the Northern and Southern states of America. In turn this will reveal the influences placed on the promotion of military technological change.

5.1 Government and Innovation

The most fundamental dilemma confronting Civil War governments' technological innovation policy – North or South; Federal or State – was whether to be interventionist or to permit the private sector to innovate at its own pace. It was the competition between these two views that produced the struggle between laissez-faire and interventionism. The former had seen government not intervene to impel pre-Civil War industrialism, whilst the latter interventionist policies circumvented older ideas of individualism and an artisan-based innovation system being central in the desperate struggle to provide the necessary products for armed conflict.(5)

Analysing the impact of government intervention on Civil War innovation is not easy. As well as diverse structures of government, there were a variety of ideological, and

4. C. Von Clausewitz, On War (London, Penguin, reprint 1984:62–63)

5. Elazan Comments in D.T. Gilchrist & W.D. Lewis, Economic Changes in the Civil War Era (Delaware, Eleutherian Mills–Hagley Foundation, 1965:97)

therefore policy,, directions that could influence military technology. Coupled with these problems, one must acknowledge that the patterns of military technical change were affected by other complex variables such as economic growth patterns, inflation, technical resources, and labour shortages. Within these variables there still remains a great deal of work to be done to examine how they actually influenced technology change. In turn, it is unclear how government policy was reciprocally influencing a broad range of societal conditions.

An important development in government actions was the Civil War's consolidation of central political authority. This was particularly so in the North. An ancillary development was the Federal government's trend towards interventionist policies. These developments critically influenced military innovation.

In the South the ability of Jefferson Davis to galvanize unity behind a central government was severely restricted. Opposition to central "Federal" jurisdiction stemmed from the strong sense of regional ideologies.(6) Any attempts to control arms procurement, manufacture and design would have had to rise above both the strong regional identities and the fragile industrial union.(7)

(A) Federal Government

Much of the study conducted on government factors will concentrate on the North. Its definable policies, innovation programs, and degree of technical change will be emphasised. Focus on the much-discussed point of how the North's political organizations assisted it to resist the South can also be assisted by such an emphasis.(8)

Under the leadership of President Lincoln, a consolidated move to preserve the Union produced a far more controlled form of centralised administration. D Brogan believes the desire to preserve the Union was a major reason the North resisted the spirit of rebellion and the South gained the righteousness necessary to hold the separate secession states, in a confederation.(9) In contrast, other analysts of the war point to the confederate states lack of will and the lack of nationalism, as the reason for the Southern defeat.(10)

6. P.D. Escott, After the Succession (Baton Rouge, Louisiana State University, 1978:47-48)

7. J.C. Cobb, Industrialization & Southern Society (Lexington, Kentucky University Press, 1984:11-12); & D. G. Faust, The Ceation of Confederate Nationalism (Baton Rouge, Louisiana State University Press, 1988:21)

8. B.D. Brogan, "The Debate on the American Civil War", Proceedings of the British Academy (Vol.49, 1963:222)

9. IBID:223

10. R.E. Beringer, H. Hattaway, A. Jones, & W.N. Still, Why the South Lost the Civil War (Athens, University of Georgia Press, 1986); Faust, The Ceation of Confederate Nationalism (1988); Escott, After the Succession (1978); & F. Owsley, State Rights in the Confederacy (Chicago, Chicago University Press, 1925)

It is perhaps not surprising, therefore, to find that the Civil War period acted as a catalyst for constitutional and legislative revolution in the growth of a truly United States federal government. Equally, when one studies the government impact on innovation, the focus becomes Northern rather than Southern, and Federal rather than State. This is not a denial of the role Confederate and State governments' played in policy directions. Instead, it is an admission, within the bounds of this thesis, for the importance of understanding why the Federal Union government could not promote military technology change to achieve victory at an earlier stage in the war.

(B) Intervention or Innovation

One of the most decisive factors that was to determine government approaches to intervention on innovation, was the increased breakdown of laissez-faire policies. This breakdown was promoted by the Agricultural Bills of 1862 and the political pragmatism that followed, as politicians became involved in State issues or financially involved in war industries that were exposed to administrative decisions. The breakdown was given added impetus when wartime arms demand at the beginning of the war, far outstripped existing production.

Throughout the war, governments consciously sought to increase the productivity of government armouries, to issue contracts to those private sector producers with the cheapest productive capacity, and to fill with overseas purchases, the shortfall between demand and local arms production.⁽¹¹⁾ Faced with the need to preserve their systems, government patronage of innovation was quickly extended beyond pre-war non-interventionist levels, to one promoting government influence.⁽¹²⁾

The legacy of laissez-faire policy was, however, never removed. Innovation policy, per se, was unheard of by Civil War politicians. Rather, within this uncharted policy field, there existed occasional and unsystematic attempts to speed industrial production. Deliberate, co-ordinated, and all-encompassing policy that could directly affect military innovation did not exist. Influence was instead expressed through a number of policy mechanisms.

11. F.A. Shannon, The Organization & Administration of the Union Army (Vol.I) (Massachusetts, Peter Smith, 1965:113-114)

12. A. Hunter-Dupree, Science in the Federal Government (Massachusetts, Belknap Press of Harvard University Press, 1957:3)

Figure 3 (13)

Policy Tool	Examples
i. Public Enterprise	Innovation by publicly owned industries, setting up of new industries, pioneering new techniques and participation in private enterprise.
ii. Scientific & Technical	Research laboratories, support associations, learned societies and research assistance.
iii. Education	General education, universities, technical education and re-education schemes.
iv. Information	Information networks, libraries, advisory and consultancy centres, liaison services and data bases.
v. Financial & Taxation	Grants, loans, subsidies, financial sharing arrangements, equipment, building or other provisions, tax exemptions, company personnel, pay-roll tax and tax allowances.
vi. Legal & Regulatory	Patents, regulations and business laws.
vii. Political Process	Planning, regional policies, division of power, control and public consultation.
viii. Procurement	Purchases and contracts and R&D assistance.
ix. Commercial & Overseas Agents purchases.	Trade agreements, tariffs, currency, regulation, defence sales and foreign

(i) Public Enterprise:

Ever since the Hall breech-loading flintlock carbine, the United States Government had been exposed to military arms innovation that had been instigated by public sector decisions.⁽¹⁴⁾ Later, with major armouries at Harpers Ferry and Springfield, the government not only adopted innovations from independent innovators such as Colt (his percussion mechanism for the 1856 Rifle Musket) and Hall (his breech-loading design improvements) but also became the vanguard of production techniques. The standardisation of parts, the placement of machines in factories to better facilitate mass production and the use of precision machine tools, all set standard models for private firms to copy.⁽¹⁵⁾

The Federal Government remained committed throughout the war to meeting arms production from its own arsenals. In August 1864 General George Ramsey (Chief of the US Ordnance Bureau) reported to the Secretary of War that whilst private contracts were being issued, government factories and foundries were still the cheapest and most desirable sources of supply.⁽¹⁶⁾

It was the Federal Government alone, with its arsenals and finance, that had established the capability to undertake the immediate production demands of 1861–1862.⁽¹⁷⁾ However, despite private contractors' expenditure of time and finances to meet government contracts, benefits from product development and manufacturing techniques, were always a side issue. The Federal Government intended contracts to be short-term solutions, until they could meet all production demands themselves.

Another source of government influence on innovation, through public enterprise, was the clothing industry. The government factories in the North were able, not only to make up the production shortfall that private firms failed to fill, but as with the small arms factories, to provide a model for division of labour, specialised production stages, and standardised quality.⁽¹⁸⁾ Wartime demand still necessitated using private contractors who often failed to match the product quality of the government factories.

14. Rothwell & Zegveld, Industrial Innovation (1982:49); & H.J. Habakkuk, American & British Technology in the Nineteenth Century (Cambridge, Cambridge University Press, 1962:94)

15. N. Rosenberg (ed), The American System of Manufacturers: The Report of the Committee on the Machinery of the United States 1855 & the Special Reports of George Wallis & Joseph Whitworth 1854 (Edinburgh, Edinburgh University Press, 1969:5)

16. Official Records, "The War of the Rebellion, A Compilation of the Official Records of the Union & Confederate Armies" (70 Vol.–127 Books) (Washington DC, Government Printing Office, 1880–1901) (Series III, Vol.IV) (1900:590)

17. M. Smith, "Military Entrepreneurship", in O. Mayr & R.C. Post (eds), Yankee Enterprise: The Rise of the American System of Manufactures (Washington D.C., Smithsonian Institution Press, 1981:94–95)

18. Rosenberg, System of Manufacturers (1963:156)

This effectively limited the government's influence on clothing manufacture and quality. Not until corrupt officials or the excess of demand over supply were removed, could contracts be issued to the most capable companies.

Throughout the war it is possible to establish a number of other areas where public, or indeed military, endeavours influenced innovation. The North's participation in hydrographical and topographical surveys, the efforts of military engineering and medical departments, and the role of military railroads and telegraph communications links, all enhanced private sector development.

ii) Science & Technical Support:

The expansion of technical knowledge in the Civil War, provided the stimulus in American history, for science and technology to become inexorably linked.

By 3 March 1863, after the war had gone on for nearly two years, the Northern Government employed the National Academy of Sciences (NAS) to advise it upon "any subject of science or art".⁽¹⁹⁾ Specifically, the Federal government recognized the importance of science in promoting wartime development. This recognition was in turn directly linked to its desire to maintain a superiority over the South's technical development. Employing this new scientific tool, the Northern government sought to:

1. negate the South's capacity to gain a military advantage through some new invention;
2. develop the pure application of science, particularly in the areas of chemistry and physics; and
3. assist in the translation of industrial research and effort, into military hardware.⁽²⁰⁾

A Permanent Commission and some five special NAS advisory committees were set up to carry out scientific studies relating to military innovation.⁽²¹⁾ The permanent commission became the representative of scientific bodies assisting the Northern war effort. The special committees had some success in developing a system of weights and measures for coinage; armouring ironclad hulls; and enhancing naval navigation through a group of investigations into magnetic deviation on ironclad-mounted compasses; a hydrometer; and sailing charts.⁽²²⁾

19. N. Reingold, "Science in the Civil War: The Permanent Commission of the Navy Department", *Isis* (Vol.49[3], No.157, September 1958:307)

20. Reingold, "Science in the Civil War"(1958:308)

21. Dupree, *Science* (1957:118)

22. IBID:144-145

Despite the success in focussing scientific and technological support, the NAS had no profound influence upon military technical innovation. This was largely due to the Federal Government's inability to harness its scientific adviser into direct support of existing innovations. Instead, it was left to the military institutions themselves, to produce innovation by technological research, carried out under government supervision.

The Naval Departments of both the North and South had been exposed to a number of innovations prior to the Civil War. Therefore, existing Northern establishments such as the Washington Naval Yard, the Naval Observatory, and the Naval Academy, spent the war expanding the practical development of pre-war research on steam propulsion, Rodman and Dahlgren heavy ordnance, navigation, and ironcladding. In the South, despite its lack of established development facilities, the need for naval innovations to circumvent the North's naval supremacy, produced an awareness of the importance of innovation.(23)

As organised research produced more significant developments on specific knowledge bases in the North, the South pursued less systematic promotion of innovations. The South still produced such innovations as torpedoes, their related weapon systems, and ironclads of varying designs, but they were forever restricted to lending assistance to schemes independent of any overall scientific or technological master plan.(24) This was unlike the Northern government, which through finances or co-ordination of private companies, could establish a development program on such an important field of endeavour, as ironclad technology.

Thus while the Southern Tredegar iron works struggled, because of limited technical assistance, the development in the North progressed, and contracts for ironclad armour plates over three-inch thick were being issued.

The 1862 reorganisation of the Northern Naval Department was able to confirm the Northern naval administrations direction under the overall guidance of Gideon Wells. He in turn promoted John S Dahlgren's Ordnance Bureau experiments and also encouraged the vital work of B F Isherwood's Naval Engineering Department, on steam engines. Therefore, a broad range of research into naval technology was possible whilst scientific understanding of existing technology continued to expand.(25)

23. G. Elliot, "Her Construction & Service" (Part I) of "The Career of the Confederate Ram Albemarle", The Century Magazine (Vol.36[3], July 1888:421)

24. V.C. Jones, The Civil War At Sea (Vol.III) "July 1863–November 1865 – The Final Effort" (New York, Holt, Rinehart & Winston, 1962:60)

25. Dupree, Science (1957:125–126)

Although the Federal Government had a degree of success in creating a research base for naval scientific and technical efforts, it cannot be said to have met with the same level of success in the army. In the South, the failures once again sprung from the lack of co-ordinated effort and the failure to set priorities. So although it was endowed with talented innovators and engineers, the South never possessed the resources or industrial capacity to induce consolidated exploitation of promising innovations.

The Southern government therefore sought to restrict involvement to the influence of specific innovative efforts and to the creation of efficient production centres. What resources were available were concentrated on exploiting existing scientific and technical knowledge, rather than on broadening it into areas of less certainty.(26) Concentration of effort was therefore achieved by avoiding technology of unknown military benefits. Instead scarce resources were focussed on combat tested technology.

Unlike the North, where industries had become well developed in both process and techniques, the Confederate Government was faced with a relatively new industrial superstructure with a very short gestation period. Thus, while weapons such as the torpedo (mine) and torpedo boat emerged from R & D efforts, these were mostly carried out without regard to government development programmes. Rather local officials gave tacit support to individual innovators.

In the North however, there were many innovative directions, all competing to gain resource allocation and government financial endorsement.

Government, through the direct patronage of President Lincoln and the Secretary of the War Department, Edwin M Stanton, often cut red tape to promote the innovations with the greatest potential.(27) However, bureaucratic obstinacy saw institutions such as the Ordnance Bureau under General James Ripley resist the involvement of even the President in the adoption of innovations.

Without systematic promotion of innovations by government, Northern agencies were too often left to devise their own means to select weapons for development. It was to be the military bureaucracy, that would provide the technical direction in the selection, testing and production supervision, of innovations for the land forces.

26. W.S. Hoole, "The Confederate Armory at Tallassee, Alabama, 1864-1865", The Alabama Review (Vol.25[1], January 1972:10-12)

27. R.V. Bruce, Lincoln & the Tools of War (Connecticut, Greenwood Press, 1973:x-xi)

iii) Education:

The contribution made by education to military technical innovation is hard to determine. In a general sense, the rise of literacy and basic education made more soldiers able to adapt to new technology. The American nation's historical pre-occupation with the practical efforts of inventors, also served to promote government concern with giving general grants to universities and utilising innovations from such institutions.

However, education's contribution to Civil War technology was not always peripheral. The development of nitre substitutes better black powder, engineering techniques, diet, medicine and meteorology, were all enhanced by university research. Government recognized these successes, but still produced no policy giving specific encouragement to education institutions undertaking projects useful for the military.

iv) Information:

There existed no deliberate government policy promoting the flow of scientific and technical information. Information was mostly transferred by means of informal information networks. Thus, although Civil War government encouraged dialogue on technical issues, it never co-ordinated miscellaneous policies dealing with education, support for scientific literature, promotion of public science displays, and sponsorship of individual research projects. Influences on the transferral of technical knowledge between individuals and broad areas of endeavour, were therefore never consciously brought within any policy framework.

v) Finance and Taxation:

It was in this area that the real impact of government participation in the private sector could be measured. The use of finances and taxation also became the key to the growth of centralised government in America. Although industrialisation had brought an emphasis on central government, during the war President Lincoln asserted not only this power shift, but reinforced it by affirming the Federal Government's role in the economy.(28)

As real wages fell, inflation bludgeoned a nation weakened by the need to finance a mass army. The North increasingly resorted to government legislation to redress economic problems.(29) Federal Government undertook to increase taxation, yet Treasury Secretary Chase was faced with problems whose scope had never before confronted an

28. Elazan Comments in Gilchrist & Lewis, Economic Changes (1965:98)

29. S.L. Engerman, "The Economic Impact of the Civil War", Explorations in Entrepreneurial History (Vol.3[3], Spring 1966:187 & 189)

industrialised nation. Revenue increased, but the expense of war far exceeded government expectations.(30) Agricultural reform was instigated through such Bills as the Homestead Act and Morrill Land Grant College in 1862. Yet agricultural expansion did not offset the monetary shortage faced by the Federal government.(31)

In 1863 the Federal Government was forced to modernise its monetary structure,(32) resulting in the National Banking (System) Act of 1863 being passed. The plethora of state banks, banknotes, and diverse procedures, was replaced by a uniform centralised system.(33) Paper money in the form of the ubiquitous 'greenback' was introduced. These treasury notes coupled with the issuing of war bonds, not only stimulated the economy, but staved off the monetary crisis until the victories at Gettysburg and Vicksburg restored confidence in the Northern economy.(34)

Overall, the banking system, with perhaps the exception of the commercial banks, remained depressed throughout the war.(35) However, it is possible to see that the North, with its industrialised base and central government, was at least able to confront its vast economic problems. Thus, while the Northern government increased the role it played in the national economy from an average 2 per cent per annum of Gross National Product in the 1850s, to a wartime average involvement of 15 per cent of GNP,(36) the Southern government was crushed under economic problems.(37)

While Jefferson Davis and Secretary of the Confederate Treasury Christopher Memminger, did try to raise taxes, gain loans, redistribute invested money out of slaves and agriculture, and issue paper money, their lack of financial expertise and a supporting industrial base, meant they failed to offset the wartime monetary crisis.(38)

The repercussion of the North's ability to at least control economic decline with finance and taxation-related policies are hard to define. Basically, no general statement regarding the impact of prevailing economic conditions on the North and South's war effort, may survive specific examination.(39)

30. P.J. Parish, *The American Civil War* (London, Eyre Methuen, 1975:354)

31. IBID:353; P. O'Brien, *The Economic Effects of the American Civil War* (London, MacMillan, 1988:56)

32. O'Brien, *Economic Effects* (1988:54)

33. J.M. McPherson, *Ordeal By Fire: The Civil War & Reconstruction* (New York, Alfred A. Knopf, 1982:204); & *The Times* August 8, 1862 in H. Brogan (ed), *The American Civil War: Extracts from The Times 1860-1865* (London, Times Books, 1975:72)

34. McPherson, *Ordeal By Fire* (1982:203-204)

35. Engerman, "Economic Impact" (1966:192)

36. McPherson, *Ordeal By Fire* (1982:200)

37. For Southern monetary policy see O'Brien, *Economic Effects* (1988:44)

38. Parish, *The American Civil War* (1975:307-315)

39. IBID:353

It is possible to see that the provision of finances to John Ericsson and the awarding of contracts to certain small arms producers did enable innovations to be put into production quickly.(40) Financing, provision of factories, and the exemption of owners from the three per cent income tax applying to those who earned over \$800.00 per annum, acted as inducements to undertake manufacture of new military technology. Specific inducement for projects desired by government was possible by direct remittance of taxes or levies on new enterprises, land grants, and in railroad development, the purchasing of corporate bonds by government, as well as the subsidising of company land purchases.(41)

Government assistance, however, was usually only obtained after the commencement of a project, rather than being used to induce additional development assist in the expansion of military technology.

vi) Legal and Regulatory:

One of the major tools used by American governments to influence the course of innovation prior to the twentieth century, was the patent system.(42) The patent system served to preserve the financial rewards for individuals, from their innovative efforts. Ordered by government legislation and enforced by the courts of law, it permitted central governments to monitor technical advances and also provided the administrative structure within which disputes could be settled, whilst technical advance still continued.(43) In shipbuilding, small arms, manufacturing techniques, and other ventures affecting military technology, unique developments were assured under this legal recognition.(44)

The patent system endeavoured to ensure a logical process in technical development was maintained, and available to be viewed by the next generation of innovators. It also guaranteed the innovator his financial rewards, even if later innovation incorporated his ideas in a way that permitted their unrealized potential to be filled. This was the case with the patented Timby turret used on the Monitor by Ericsson, the Colt

40. E.B. Potter & C.W. Nimitz (eds), Sea Power: A Naval History (New Jersey, Prentice-Hall, 1961:265); & W.T. Sherman (General, U.S. Army), "The Grand Strategy of the Rebellion" The Century Magazine, (Vol.35[4], February 1888:141)

41. C. Cochran, "Did the Civil War Retard Industrialization?", in R. Andreano (ed), The Economic Impact of the American Civil War (Cambridge, Schenkman, 1967:175)

42. Rothwell & Zegveld, Industrial Innovation (1982:82)

43. E.D. Fite, Social & Industrial Conditions in the North During the Civil War (New York, Frederick Ungar, 1963:100)

44. The Civil War to a certain extent did promote infringements of patents that had previously limited design work. This happened with the Colt patent on the revolver pistol, see C. Blair, Pollard's History of Firearms (New York, MacMillan, 1983:232-233)

percussion lock on the 1856 Springfield rifle, and Rollin White's bored-through revolver cylinder which Smith and Wesson perfected with rimfire rounds.

The patent system also had one very negative affect. Inventors were often forced to develop military technical designs (cartridges and rifle actions in particular) that avoided current patents. Thus to avoid infringing patents or paying royalties, they eschewed the development of sound technical ideas with real potential.

The rigid enforcement of patents by government also encouraged individuals and small firms to attempt to develop new technology. Knowing the patent system would protect their discoveries, technologists could risk financial and important resources, with the knowledge that the gains could be enormous. In effect then, large companies were only marginally better off than any small firm undertaking technical research and development.

It is perhaps because of the use of the patent system and the lack of rigid anti-trust legislation, that the individual technologists and entrepreneurs operating in military technological development, consolidated their efforts under the sponsorship of a number of large companies. Firms such as Winchester, for instance, found it easier to sponsor innovators to work on the lever action Winchester repeating rifle concept, than to buy their patented designs after innovation had occurred. Thus a whole new area of corporate research conducted by numerous individual technologists became the new core concern of the patent system.(45)

vii) Political Process:

The most profound policy trend during the Civil War was the increased power of the central legislature. From the perspective of how centralization impacted on technological changes, it is important to note that while the States continued to exert important influences on the political system, it was the Federal Government that gained from the centralised shift in legislative power. It was able to bring to bear upon innovation, an influence that took the 'nation's welfare' as the central motive and circumvented reliance upon decentralised State legislatures to organise the war effort. Through public enterprise, research assistance, broad financial and taxation policies, and issuing of contracts, the Federal Government's policy machinery consolidated its new pre-eminence in shaping the nation's direction in technological endeavour.

45. V.D. Stockbridge, Digest of Patents Relating to Breech-loading & Magazine Small Arms (Except Revolvers), Granted in the United States from 1836-1873, Inclusive (Washington DC, U.S. Patents Office, 1874)

The growth of central, federal government has been challenged by those who believe the Confederacy was divided by individual states demanding states' rights. These States-Rights theorists maintain that the Confederate states were devoid of sufficient national identity to survive wartime combat.(46) Thus industrial as well as military forces suffered from a lack of central political direction. This thesis has in its own turn being challenged by more recent schools of thought, that indicate the Southern states still achieved a high degree of central political direction.(47)

One must be careful in accrediting central governments, on either side of the Civil War political fence, with unlimited expansion. It should not be assumed that in order to shape technological change, the Union government made a conscious movement towards greater market intervention. American Governments of the Civil War still did not comprehensively understand either the theory of market competition or know how to co-ordinate it, during their irregular progress towards industrialisation.(48) Nor did they consciously produce a policy package that shaped innovations. Basically, the rate of successful military innovation was influenced by a basket of changes to centralise government organisation and control, including adaption of government regulations affecting industrialisation and the overall stimulation of productive capacity.

In the marketplace, state governments could and did play a crucial role in stimulating industry. Because industries were highly localised, with for instance, small arms and boot and shoe industries concentrated in Massachusetts and iron and steel industries in Pennsylvania,(49) State Government could directly influence local conditions. In particular, it played an important role in infrastructure support. This role ironically, was not as important as its role in stimulating innovation when governments competed against each other in the open market to secure arms technology.

Oligopsonistic markets (exclusive markets with a number of government buyers) saw states vie against each other, and against the central governments of the North and South, to secure the best available weapons to arm their militias.(50) This competition not only pushed up market prices, but also induced companies to take up slack productive capacity while also exploring new technology as a means of securing new commercial products.

Innovations such as the Spencer and Henry repeating rifles were only originally used in combat, because state governments were sympathetic to local manufacturing firms and

46. Owsley, State Rights in the Confederacy (1925)

47. Beringer (et al), Why the South Lost (1986:218); & O'Brien, Economic Effects (1988:17ff)

48. B. Collins, The Origins of the American Civil War (London, Edward Arnold, 1981:29)

49. IBID:29-30

50. Shannon, Organization & Administration (Vol.I) (1965:115)

because they saw the weapons as valid, cheaper alternatives to weapons that would have to be bought in competition with the Federal Government. Thus, those states with available capital, secured good weapons, often on contract, so as to avoid paying artificially high prices for older-type weapons that the Federal Government and other State governments desired.

The popularity of the Spencer and Henry rifles reinforced these State Governments' purchases of technical innovations whilst also confirming the early sponsorship of advanced innovative efforts by commercial manufacturers.

viii) Procurement:

The Federal Government exerted a profound influence on technical development through its use of procurement and contractual arrangements. During the Civil War these arrangements provided a stable market demand that reduced the producer's risk, by making it unnecessary to compete on the open market for government sales. Unfortunately, politicians and bureaucrats, military and civilian alike, were without a formalised contract system, whereby the chosen product was tested and assessed before the contract was awarded. Thus those who supervised innovation and the introduction of new military technology used the contract system to reinforce their narrow view of whose interests they perceived themselves to be promoting. Sometimes their lack of technical skill saw them fail to promote the best available product.

Contracts could, however, reduce market uncertainties and shield manufacturers and government alike, from the economic changes and price fluctuations, that open market competition caused. Contracts, nevertheless, still did not guarantee industry's commitment to innovation. Sales and the filling of contracts often resulted in companies lacking the capacity to redirect resources into research or development. Equally, while the Northern central administration remained reluctant to award contracts on new technology such as repeating small arms, few companies took the risk of developing new technology that would have to be sold on the open market.

By 1863 the Northern government had put an end to the mass importation of weapons. Instead, the North expanded productive capacity in its government foundries and factories, and only when there existed a shortfall in military demand, did they issue contracts for certain weapons.

Although the Federal Government became more prepared to issue contracts for weapons, they usually procured only weapons (such as repeating and advanced breech-loading rifles) that could not be manufactured in their foundries. By 1863 the

technology of these arms was more known and the designs were generally considered less than radical in their design.

Contracts did, however, confirm these new technical advances as commercially viable. Also the guarantee of prices and the breakdown in government reluctance to issue contracts for new technical products, permitted companies with organisational or process shortfalls, to secure contracts for refined weapons technology that, once in production, could enable them to compete efficiently on the open market.(51)

Contracts did, however, possess the capacity to stimulate manufacturing. Yet the lack of an articulated system for issuing government contracts inhibited the promotion of the best available technical innovations. Coupled with the existing political patronage, corruption,(52) and companies' capacity to sell known, older types of technology, the contract system's capacity to promote technical innovation was more often abused than properly used.

ix) Commercial and Overseas Agents:

The early stages of the Civil War (until 1863) saw a heavy reliance being placed upon overseas agents to secure the weapons necessary to fill the arsenals of both the Northern and Southern armies. These men often worked without buying guide-lines or set standards, and were not at all impervious to corruption.

In Europe, the attempts to buy arms resulted in huge leaps in European weapons' resale value. Faced with filling buying lists that stated numbers of arms and not their quality, American agents payed inflated prices for obsolete weapons cast off by European nations.(53)

The efforts of these purchasing agents affected domestic arms innovation in a twofold way. Firstly, the lack of quality imported arms reduced the impact technology transfer had on stimulating American development. Thus whilst the French and Prussians experimented with bolt-action rifles, the American forces were very slow to develop such designs.(See Appendix 20, on bolt action rifle development in the Civil War)

Some weapons that were introduced with novel technical features, did influence domestic American technologists. The development of rimfire revolvers benefited from

51. Rothwell & Zegveld, Industrial Innovation (1982:99)

52. Discussion on the Ordnance & Commissary Department are in McPherson, Ordeal By Fire (1982:198)

53. Shannon, Organization & Administration (Vol.I) (1965:119-120); & L.M. Sears, "A Confederate Diplomat at the Court of Napoleon III", American Historical Review (Vol.26[2] January 1921:255-281)

designers' exposure to imported French revolvers such as the Le Fauchaux, Le Mat (product of an American designer working from France), and Perrin designs, and artillery designers were encouraged by the importation of foreign breech-loading rifled ordnance and related ammunition. But instead of promoting technological innovation with novel designs, both Northern and Southern governments clogged the battlefield with expensive, low-quality imported weapons that diverted demand from new local small-arms designs. While so many foreign arms abounded, governments were reluctant to risk introducing unknown technology with an uncertain lead time between ordering and delivery.

The second major impact of large overseas procurements by agents was an increase in the American Government's overseas debt, which not only lowered its purchasing power overseas but affected the impact of government financial policies on the local economy. Paradoxically, it was this lack of overseas purchasing power that was in 1863 to stimulate government administration to issue local contracts and even to compete on the domestic open market.⁽⁵⁴⁾ This in effect freed government capital to re-invest in domestic industry and inject new life into the arms manufacturers who were developing new technology.

(C) Government And Technology Change

Throughout the Civil War, governments failed to adopt a systematic approach to innovation policy. Nevertheless, despite policy being disjointed, it did greatly influence technical developments. Because of the Federal Government's increasingly central role in the affairs of the nation and its policy in public enterprise, patents, finance and taxation, and contracts, it was able to directly manipulate the course of military technology change, not always with conscious regard to the outcome.

Administratively, these policies occurred outside the influence of any one institution. Thus while the policy process was diverse, the implementation of the total policy could not fall under the control of one agency. Such problems were compounded in the North as government and military organizations worked separately from one another. Many negative factors inevitably arose. The lag between discovery and exploitation of useful military innovations was lengthened because of the failure to issue guide-lines for the adoption of new weapons. It was rare for any consideration to be given to the marriage between newly introduced weapons and existing weapons technology. Contracts were

54. J.F. Baenteli, "Civil War Revolvers", in National Rifle Association of America, Civil War Small Arms, (Washington, NRAA, 1960:9)

usually just issued to secure the arms that could not be immediately supplied from existing (government) sources.(55)

The closest the North came to having such a policy was when General James Ripley of the Ordnance Bureau blocked efforts that were intent on introducing new weapon innovations. In effect, then, policies produced haphazard promotion of some innovative effort but important agencies such as the War Department and the Treasury were often pursuing their own interests, divorced from important technical changes.

In summary, then, the Northern Civil War public sector illustrated that the early, positive promotion of military innovation could be conducted by interventionist policy. Yet the failure to develop innovation policy often meant that arms manufacturers were never able to attract enough government funds to develop and promote new weapons technology. This resulted in a lack of emphasis on high-risk research into inventions that could dramatically alter existing military technical developments. This trend was reinforced by the Washington administration's inability to use its unique industrial base and pure research assets, to promote Civil War military technical change. The North could have achieved this by focussing its policies on military innovation or by clearly delineating military demand.

Innovation policy throughout the war was instead, restricted by random and uncoordinated policies that were based around a limited understanding of how technical change could itself be used as a weapon in war.

5.2 Industrial Environment

A single enigma has dominated discussions of Civil War industry: why did the North not use its obvious industrial superiority to destroy the Confederacy before 1865? One major school of thought headed by T C Cochran believed that the failure was due to the retarding of industrialisation by Civil War factors:

By modern standards, the Civil War was still unmechanized. It was fought with rifles, bayonet, and sabres by men on foot or horseback. Artillery was more used than in previous wars but was still a relatively minor consumer of iron and steel. The railroad was also brought into use, but the building of military lines offset only a small percentage of the overall drop from the pre-war level of civilian railroad construction. Had all this not been true, the Confederacy with its small industrial development could never have fought back through four years of increasingly effective blockade.(56)

The "Cochran Thesis" poses many questions in itself. This is inevitable, given the lack of comprehensive figures on industrial and economic indicators and the inconsistent

55. C. L. Davis, *Arming the Union* (Port Washington, Kennikat Press, 1973:vi)

56. Cochran, "Did the Civil War Retard Industrialization?" (1967:173-174)

interpretations so many authors have subsequently lent to these figures.(57) However, the debate has an important bearing upon our understanding of how the general industrial environment affected military technical innovation. Firstly, can we simply state that although in 1861 the North possessed the capacity to produce breech-loaders for an army of 600,000,(58) it did not do so because the Civil War produced conditions that were retarding manufacturing enterprise?

Secondly, if we accept the basic tenet of Cochran's thesis and the contributions to the argument lent by others such as S L Engerman and even V S Clark's outstanding History of Manufacture in the United States,(59) then during the war not only were there no radical changes to domestic industry and production methods, but war demand basically did not revolutionise industry.(60)

If this is so, can we therefore finally suggest innovation in military technology was inhibited by a lack of enterprise in a manufacturing environment that was pre-occupied with converting existing resources to fill production shortfalls with military demand?

Answers to these first two questions will assist us more fully to establish the industrial environment's affect on military technical innovation. Yet because of vagaries in the link between innovation and industrial growth, this study will have to establish a number of prior factors. Thus it will be important to examine the American System of Manufacturers (ASM) and the machine-tool industry to give an indication of the pre-war techniques of industrial production. From this point, the impact on war industries in the North and the South can be assessed.

Only after this study will it be possible to establish whether innovations were retarded within this environment. How, if at all, did specific industries affect military technology change? Can a link be established between environmental factors and the ability of industry to produce innovations utilizing advanced technical knowledge?

(A) The American System of Manufactures (ASM)

Very early in the nineteenth century America produced a system of manufacture that was to represent one of the greatest spurs to the nation's quest for industrial might.

57. O'Brien, Economic Effects (1988:9-10, & 52)

58. J. Coggins, Arms & Equipment of the Civil War (New York, Double Day, 1962:28); McPherson, Ordeal By Fire (1982:197); & W.R. Brock, Conflict & Transformation: The United States 1844-1877 (London, Penguin, 1978:285)

59. Engerman, "Economic Impact" (1966); & V.S. Clark, History of Manufactures in the United States (Vol. I & II) (Washington D.C., Carnegie Institute of Washington, 1928)

60. V.S. Clark, "Manufacturing Development during the Civil War", in Andreano, The Economic Impact of the American Civil War (1967:63); & Engerman, "Economic Impact" (1966:184)

This so-called ASM was initiated by the efforts of small-arms designers Eli Whitney and John Hancock Hall, who sought to produce muskets with standardised, interchangeable parts.(61)

The ASM by 1860, had affected other industries so that manufacturers were irrevocably restructured according to its guiding principles.(62) The system involved the characteristics of mass manufacture by power-driven machinery and by machinery especially designed to make particular parts at each phase of the production process, and was were guided by the principle of interchangeable parts.(63) By the 1850s, embodied with this new "machine consciousness", industries such as the watch, clock, lock, tools, sewing machine, and small-arms industries, were changing the face not only of manufacturing enterprise, but also of American society.(64)

At the start of the Civil War there already existed the precision tools and gauges, as well as the necessary principles of mass manufacture, to produce new products.(65) By 1861, small-arms manufacturers such as Colt, Robbins & Lawrence,(66) Sharps, Remington, George S Lincoln, and Providence Tool Company,(67) already possessed the knowledge and the principles necessary to reorganise machinery to meet wartime demand. While it may be true that the Civil War was never a dynamic force in altering production methods, it did confirm the technical trends in human and mechanized resources use, management techniques, and industrial needs initiated by the ASM.(68)

(B) Machine Tools

Machine tools and the machine-tool industry respectively, stand as examples of a necessary part of industrialisation and as a representative of the impact industrialisation had on industry.(69) Machine tools were, therefore, central to

61. R.S. Woodbury, "The Legend of Eli Whitney & Interchangeable Parts", Technology & Culture (Vol.1[1], Summer 1959-60:235-253); J.E. Sawyer, "The Social Basis of the American System of Manufacturing", Journal of Economic History (Vol.14[4], 1954:361-379); & D.F. Butler, United States Firearms: The First Century, 1776-1875 (New York, Winchester Press, 1971)

62. Sawyer, "The Social Basis of the American System of Manufacturing" (1954:370)

63. Woodbury, "The Legend of Eli Whitney & Interchangeable Parts" (1959-60:250)

64. Smith, "Military Entrepreneurship" (1981:89)

65. Sawyer, "The Social Basis of the American System of Manufacturing" (1954:370)

66. S. Engelbourg, "The Economic Impact of the Civil War on Manufacturing Enterprise", Business History (Vol.21[1-2], 1979:150)

67. Smith, "Military Entrepreneurship" (1981:88)

68. Rosenberg, System of Manufacturers (1969:128-129); Engelbourg, "The Economic Impact of the Civil War on Manufacturing Enterprise" (1979:151); & Sawyer, "The Social Basis of the American System of Manufacturing" (1954:364)

69. Habakkuk, American & British Technology (1962:19-21)

providing the industrial capacity to produce new products, and were themselves a source of innovation and expansion in manufacturing enterprise.(70)

N Rosenberg considers that machine tools were:

...the most important members of the larger classification of power driven metal working machinery. The basic distinction is that machine tools shape metal through the use of a cutting tool and the progressive cutting away of chips, whereas other metal working machinery shapes metal without the use of a cutting tool, by pressing (forming, stamping, punching), forging, bending, shearing etc.(71)

Before the Civil War these functions had been increasingly important because of the growing influence of the ASM. Primarily, machine tools provided the means to make the machinery necessary to sustain the new machine based manufacture-type industries.(72) As the ASM instituted specialised production of parts at different phases of the production process, so the machine tools and their manufactured machines replaced artisans who made each product individually. Thus machine tools produced specialised turning, boring, drilling, milling, planing, grinding, polishing and other functions.(73) Finally, the machine tool industry expanded with the ASM and confirmed the "machine consciousness" that produced a transformation of the technical features of American manufacturing.(74)

The utilisation of the Springfield Armoury's productive capacity to meet wartime demand, was not so much just a sudden revolutionary use of machinery, but a realisation of the productive capacity established by machine-tool evolution in the 1840s and 1850s. Equally, the successful application of these production facilities showed how other industries could build upon existing technical developments (75) without radically altering the production methods the ASM had inculcated into industry over two decades.(76)

70. N. Rosenberg, "Technological Change in the Machine Tool Industry 1840-1910", The Journal of Economic History (Vol.23[4], December 1963:416)

71. IBID:417

72. IBID:425

73. IBID:423

74. IBID:433; & Clark, History of Manufactures (Vol. II) (1928:22)

75. Clark, History of Manufactures (Vol. II) (1928:64)

76. Smith, "Military Entrepreneurship" (1981:89)

(C) War Industries

It is not possible to surpass V S Clark's summary of the Civil War's impact on industry. He states that:

In a word, the factories and work shops of New England and the Central States were already prepared to equip armies and to replace the waste of modern war. We did not have to create these establishments when hostilities began, but only to transform them to military use.(77)

Under such description the Civil War did not create an a priori catalyst for industrial expansion. Because of the development of new manufacturing techniques and the inroads made by the use of machine tools, more specialised areas of mass production techniques were being applied to meet the new wartime demands.

In particular, the scarcity of labour became more critical during the Civil War. Thus the drift towards labour-saving machinery that the ASM precipitated was accelerated.(78) In turn, this resulted in increased demands on the machine-tool industry, increased innovation in the production and use of machinery, reduced cost of machinery manufacture, and overall, an increase in employees' productivity.(79) This phase of expansion during the war provided the realisation of pre-war changes to production methods and spurred changes to production methods resulting in improvements to the techniques of production.(80)

These technical changes are seen by S L Engerman (81) as not being war-related. Rather, he believes the changes were less related to war industries than to consumer goods industries or industries whose demands were derived from that of consumer products.(82) He suggests, therefore, that the:

techniques of war were pre-modern and that any mechanisation in heavy industries due to war demands was of minor importance, in contrast with twentieth century wars.(83)

This suggests that industries classified as war-related were subject to a variety of war-induced influences. As these would affect military innovation in their industries, it is perhaps useful to examine the key war industries of small arms and munitions, iron and steel, rail transport, clothing, and the boot and shoe manufacturers.

77. Clark, History of Manufactures (Vol. II) (1928:8)

78. Habakkuk, American & British Technology (1962:8)

79. IBID:21

80. IBID:105; & Clark, History of Manufactures (Vol. II) (1928:64)

81. Engerman, "Economic Impact" (1966:176 & 199)

82. IBID:184 & 195

83. IBID:184

(i) The Small Arms and Munitions Industry. – It is difficult to assess how much impact the war had on this area of manufacturing. Basic factors such as advances in precision tools and engineering expertise can be attributed to the war. Certainly, technical development was spurred by the war despite it being an incremental process rather than a radical leap forward.⁽⁸⁴⁾ The necessary machine tools and techniques existed in 1861 to fill the same contracts as were issued in 1865, for 78,100 repeating rifles and 11,850 single-shot breech-loaders.⁽⁸⁵⁾

The irony of the Civil War small-arms industry is not the existence of established production knowledge but of its non-exploitation during the war. This irony is reflected in the study of the British Committee that investigated the United States small-arms industry in the early 1850s. The British had found that the Crimean War had created massive problems for military technology production.⁽⁸⁶⁾ With what they learnt in America, the implementation of the ASM techniques, mass-production technology, precision machine tools, and the adoption of better small arms designs,⁽⁸⁷⁾ the British largely resolved their military production problems.

The Americans, who were the originators of the ASM and had the system well before the Civil War, still had not fully exploited the system. In fact, from 1861 until 1863, both the South and, more ironically, the North, were buying the English Enfield muzzle-loading percussion rifle at 25 dollars each. Yet it was made at the Birmingham Small Arms factory and was directly based on the British Investigating Committee's American findings, that had a decade earlier studied production of the US Springfield 1857 muzzle-loading percussion rifle.⁽⁸⁸⁾ Ironically, in 1862 the cost of manufacturing the latest US Springfield rifle was still only three-quarters of the purchase price for the Enfield rifle.

The final irony was that in 1856 the British Committee had examined repeating (Colt rifle) and breech-loading (Sharps and Perry Carbines) designs and had thought they would shape the types of weapons in future army arsenals.⁽⁸⁹⁾ This scenario was repeated with the Committee's surprise discovery that the United States had vastly superior gun-casting techniques to its own.⁽⁹⁰⁾ The Committee considered the US

84. Clark, "Manufacturing Development" (1962:64); & Engelbourg, "The Economic Impact of the Civil War on Manufacturing Enterprise" (1979:150)

85. Shannon, Organization & Administration (Vol.I) (1965:141)

86. W.H. McNeill, The Pursuit of Power: Technology, Armed Force & Society Since AD 1000 (Oxford, Basil Blackwell, 1982:234)

87. McNeill, The Pursuit of Power (1982:235); & Rosenberg, System of Manufacturers (1969:Chapter 3)

88. Rosenberg, System of Manufacturers 1969:124)

89. IBID:123-125:

90. IBID:158-159

ability to mass-produce good quality weapons without enormous amounts of expensive labour, as extremely advanced.(91)

However, while the British were to introduce United States machinery and engineers to change their system of arms manufacture, the potential of arms production and the ASM was still not fully accepted in America. Production potential was, therefore, never realised prior to the Civil War.

Some advances in munitions occurred during the Civil War. Rimfire and centre-fire cartridges were developed from a few pre-war experimental models, and the powder and explosives industries expanded their wartime production to meet the new demand. Both sides also had to develop nitre works to manufacture substitute saltpetre or to rationalise their inefficient production methods.(92)

The story of Civil War small-arms manufacture is not necessarily one of unlimited growth in industrial performance. For instance, the manufacture of breech-loaders was often inhibited by an inability to machine precision parts so as to make interchangeable barrel and breeches, in ways that assured precise fitting.(93) Repeating rifles and metallic self-contained ammunition designs were often too delicately made to survive the rigours of the battlefield. Some precision weapons such as snipers' rifles still had to be produced by individuals skilled enough to precisely manufacture accurate rifles.

Modifications to weapons designs, the reduction in moving parts and the improvements to precision machining did combine over the length of the war to produce high production standards.(94) The BLR and repeating rifle in general, and specific designs such as the Gatling Gun and Henry repeating rifle, certainly were benefited by the improvements to machine tools. These small arms and machine-tool advances were not universal. They were not to spread throughout the whole industry until after the war.(95)

Innovation was promoted in specialised techniques and special products. This was especially so where efficiency was increased, cost decreased, or a product capable of gaining a government contract could be competitively manufactured.

91. IBID:175

92. Coggins, Arms & Equipment of the Civil War (1962:65)

93. Shannon, Organization & Administration (Vol.I) (1965:130)

94. Davis, Arming The Union (1973:119)

95. Engelbourg, "The Economic Impact of the Civil War on Manufacturing Enterprise" (1979:150-151)

(ii) The Iron & Steel Industry. – Unlike the small-arms and munitions industries, this was marked by its total lack of innovative stimulus resulting from the war.(96)

The industry had no major product or process innovations that could mark the war era as a major period of technical growth. As wartime demand for iron increased, it still could not offset the very large decrease in pre-war levels created by railroad demand.(97) Small-arms production also demanded increased industrial capacity, but although sponsoring the production of more refined, high quality wrought-iron and experiments with steel weapons,(98) production levels in the North barely offset the loss of the export and Southern markets.(99) Despite increased domestic production of rifle barrels, it still only marginally affected the rate at which rifle barrels were imported from Great Britain.(100)

It was only in the production of pig iron that output by 1863 matched 1860 figures and continued to rise.(101) Experimentation with the Bessemer steel process and improvements in metallurgy were not extensive enough to improve iron production figures. Mainly because of patent conflicts, the Bessemer steel process was used only to manufacture swords and some railroad tracks.(102)

Improved metallurgical knowledge did promote an increase in gun size. The 1861 Rodman gun was a 15-Inch calibre, 25-ton gun firing a 337-pound shot. By 1865 a 20-Inch calibre version weighing 50 tons and firing a massive 1,000-pound shot was being cast in the same foundries as its 1861 forerunner. Yet these and other experiments with heavy ordnance were unco-ordinated and more than matched by European experiments by Armstrong and Whitworth in England and by Krupp in Germany. Although not necessarily officially accepted, European advances created new weapon designs, better casting techniques, and even all-steel manufacture.

In the manufacture of ironclads, required the commitment of production resources to make iron plate. Improvements in wrought-iron production provided increased labour savings, increased iron width, better machine tools and an increased thickness in iron plates from 1.5 inches to the 5-inch plates being produced by the war's end.(103) However, in 1862 machines could tool and shear only 1.5-inch-thick plate.(104) At this

96. IBID:153

97. IBID:153-154

98. Clark, History of Manufactures (Vol. II) (1928:17)

99. Engelbourg, "The Economic Impact of the Civil War on Manufacturing Enterprise" 1979:151)

100. Clark, "Manufacturing Development" (1967:63)

101. Clark, History of Manufactures (Vol. II) (1928:15 Sec Chart)

102. IBID:19-20

103. IBID:19

104. IBID:18

time Great Britain had the capacity to roll and cut up to 20 tons of 12-inch-thick iron plate.(105)

Although the iron industry enhanced its pig iron and wrought- or plate-iron production, the level of these advances was small. Similarly, these advancements in technical knowledge did not stimulate advances in steel production.(106) Yet in 1865 production of some 15,862 tons of steel railroad track illustrated the burgeoning capacity of the industry.(107) Government requirements and standards set in 1864 and 1865 also promoted the greater use of precision machine tools, uniform production standards, and a loose confederation in the steel industries.(108)

It would appear that while technical development in the steel industry was restricted, its potential was actually increasing. This is in contrast to the iron industry where technical and process innovations did influence production but the average production figures during the war still fell below that achieved thirty years earlier during three weeks of 1832!(109)

(iii) Clothing Industry. – The clothing industry reflected the wartime fate of most textile-related companies. With the exception of the wool industry, the story was one of declining markets and production.(110)

The production of men's clothing was directly stimulated by the need to provide soldiers' uniforms. Wool consumption in the North rose from a pre-war level of 85 million pounds to a peak of 200 million pounds in 1865.(111) Of this increase, only 75 million pounds was to fill the military demand whilst the other 138 million pounds was sold to civilian consumers.(112)

Wartime demand had little effect on other textile industries such as cotton. Increases in the wool industry could not offset the textile industry's overall 30 per cent decline in output between 1860 and 1865.(113)

In the advances made in clothing during the war, the strongest was the trend towards better quality products. The greatest support for the clothing industry was instigated by government factories. However, the standardisation of labour activities and

105. Clark, "Manufacturing Development during the Civil War" (1967:64)

106. Engelbourg, "The Economic Impact of the Civil War on Manufacturing Enterprise" (1979:154)

107. Clark, History of Manufactures (Vol. II) (1928:20)

108. IBID:20

109. Engerman, "Economic Impact" (1966:195–196)

110. IBID:186

111. IBID:185; & Fite, Social & Industrial Conditions (1963:84)

112. Fite, Social & Industrial Conditions (1963:84)

113. Engerman, "Economic Impact" (1966:186)

efficiency in the whole industry was criminally inadequate during the early phase of the war. The word "shoddy" became popularly applied to uniforms made from pulped linen and rag, that were sold in the early stages of the war to fill government contracts. They were so poorly made that they dissolved in the rain.(114)

Under the influence of government enterprises, better organisation and management of procurement, and the expanded use of the innovative sewing machine, producers of wool, cotton, leather and linen at least improved the clothing industry's productive efficiency.(115)

(iv) The Shoe and Boot Industry. – Like the clothing industry, it benefited from exposure to government enterprise and the invention of the sewing machine and developed more efficient wartime production methods.(116) Manpower fell from 77,827 to 55,160 people in the decade between 1855 and 1865.(117) In the same period, overall output also fell, from 45 million pairs to 35 million pairs.(118)

Unlike the clothing industry, where machinery increased productivity, the shoe and boot industry's figures are more ambiguous. They seem to indicate that despite improvements in manufacturing technology productivity remained relatively stable.(119) The real benefits lay in the development of standardised production to fill military contracts, while steam-driven machinery made organisations more efficient. These benefits were, however, not necessarily common to the industry as a whole. As more than half the nation's boots and shoes were manufactured in Massachusetts (along with one-third of the textile output and one-quarter of the wool output), the ability of industries to exploit technical advances seems to have been influenced by regional locations.(120)

Thus although the lack of growth in wartime production over pre-war figures indicates a sector decline, the industry went through a period of quality, production, and efficiency development, that was induced by the commitment of some companies to technical advances.

114. Fite, Social & Industrial Conditions (1963:85)

115. IBID:86–88

116. Engelbourg, "The Economic Impact of the Civil War on Manufacturing Enterprise" (1979:154–155)

117. Engerman, "Economic Impact" (1966:185)

118. IBID:185

119. Engelbourg, "The Economic Impact of the Civil War on Manufacturing Enterprise" (1979:154–155)

120. Engerman, "Economic Impact" (1966:185)

(D) Confederate Wartime Industries

Before assessing the overall Civil War industrial environment it is perhaps necessary, for the sake of a more complete picture and an aid to comparisons, to study briefly Confederate industry.

The Confederacy was hampered by its lack of a substantial wartime industrial base and a decline in all major sectors of industry, exacerbated by a shrinkage of accumulated capital.(121) In fact, the story of manufacturing in the South is one of steady wartime destruction or decline, and only rare examples of increased industrial activity in new technologies.(122)

However, there did exist some government support and innovative centres of production. The Confederate Government was always faced with wartime demand outstripping industrial capacity, yet it succeeded in at least facilitating individual innovations such as submarines, ironclads, and torpedoes. Unlike the North, these industries had to concentrate productive capacity on military needs in preference to consumer production. Successful operations included such centres as the Tredegar iron works at Richmond, which produced field cannons, two-inch iron plates, and rifle barrels. Efficient production was also achieved at the Augusta powder mill and the Nashville nitre works.(123)

Large small-arms industries were also built. Some 25 per cent of annual Confederate small-arms production were produced at Richmond.(124) The next largest centre of production was Fayetteville, where the captured Harpers Ferry armoury equipment was located. The remaining arms production was carried out at the expanded works at Augusta, Charleston, Columbus, Macon, Atlanta, Selma, and later in Tallassee when the Selma works were moved there.(125)

These small-arms works and other smaller works produced some 330,000 weapons to meet the Confederate Ordnance Bureau's orders and made another 270,000 for state militias.(126) However, throughout the war the Confederates relied heavily upon arms

121. Fite, Social & Industrial Conditions (1963:159)

122. Engerman, "Economic Impact" (1966:182); & Clark, History of Manufactures (Vol. II) (1928:41)

123. See Gorgas in C.E. Fuller & R.D. Steuart, Firearms of the Confederacy (West Virginia, Standard, 1944:116)

124. IBID:131

125. IBID:113 & 115; Hoole, "The Confederate Armory at Tallassee, Alabama, 1864-1865" (1972:3); & C. Eaton, A History of the Southern Confederacy (New York, Free Press, 1954:133)

126. Eaton, A History of the Southern Confederacy (1954:133)

from Europe that evaded the blockade. These in turn were supplemented by great numbers of captured enemy weapons.

Many shortages affected production in Southern industries. Aside from labour and capital shortages, there also existed a lack of oil lubricants and a demand for sulphur, lead, and saltpetre, that the Nitre and Mining Bureau of the Southern War Department made valiant efforts to offset. Southern iron works were only ever able to satisfy around a half of military demand.(127)

These factors limited 1864 small-arms production to 20,000 stands (a weapon plus attachments and associated equipment for one man) despite a projected capacity of 55,000 stands.(128) In the production of ironclads, the lack of manpower and iron plating also made for severe restrictions.(129) Replacements for worn rail lines or old rolling stock were virtually curtailed after 1863 because of the lack of rolled or refined metals.(130)

The Confederate industrial environment was, then, one that encompassed industries trying to meet increased military demands but possessing neither an adequate production infrastructure built up prior to the war, nor sufficient wartime resources to meet these demands. Additionally, the concentration of scarce resources on known products and processes, stagnated innovation in the industrial sector.(131)

It was not until after the war that the South began to shift towards a more unified process of industrialization. This process of change was driven from two opposing forces. One the one hand the North, with its vigorous new economic order, enforced reconstruction and a new industrial era on Southern society.(132) On the other hand many crusading Southerners promoted economic modernization and industrialization as the only way Southern independence could ever be gained.(133)

127. Gorgas in Fuller & Steuart, Firearms of the Confederacy (1944:105); & Clark, History of Manufactures (Vol. II) (1928:42)

128. Clark, History of Manufactures (Vol. II) (1928:45)

129. IBID:46; V.C. Jones, The Civil War At Sea (Vol.I) "January 1861–March 1862 – The Blockaders" (New York, Holt, Rinehart & Winston, 1960:183); & Elliot, "Her Construction & Service" (1888:421)

130. G.E. Turner, Victory Rode the Rails: The Strategic Place of the Railroads in the Civil War (Connecticut, Greenwood Press, 1972:241)

131. Clark, History of Manufactures (Vol. II) (1928:53)

132. J.H. Franklin, Reconstruction: After the Civil War (Chicago, Chicago University Press, 1964:7)

133. J. C. Cobb, Industrialization & Southern Society 1877–1984 (Lexington, University of Kentucky Press, 1984:11 & 13)

(E) Industry and Military Innovation

Throughout the Civil War, industry continued to be exposed to and involved in, technical innovation. The war directly stimulated many miscellaneous manufacturers such as producers of soap, salt, petrol, kerosene, oil lubricants, chemicals, paper and sugar.(134) Although the stimulation of industrial activity can be more clearly seen in the North than in the South, the relationship between war and its catalytic impact on industrial growth cannot be simply established.

Put into a generalised hypothesis, one gets back to the points made by such analysts as V S Clark and T C Cochran that growth, if it did occur, usually took up only productive slack in existing industries. Mostly the war had an adverse impact on industrial output and did not lift production beyond pre-1857 depression levels. The sustaining production methods and the pre-1857 infrastructure of industry also remained relatively unchanged through the war years. Consistent with this point is the fact that increased technical development in machinery and processes produced more uniform progress in innovations that were concentrated in the areas of small-arms, machine tools, naval engineering, and in some clothing and footwear industries.

However, while organizations concentrated their research and development on technology with established markets, the eventual effect was to limit the expansion of new products. Thus the innovation base itself grew only slowly.(135)

This belief was held by V S Clark when he stated that:

...the stress of the Civil War...like a whirlpool in a river neither contributed to the volume of our production, nor permanently diverted its direction.(136)

Pursued to its conclusion, such a belief supports the argument that the war never created a level of demand or degree of new products that could induce radical industrial growth or development. The war, of itself, could induce firms to transfer resources to meet military demand, but this process involved little innovative effort and rarely saw innovations responsible for increasing the scale of an organization.(137)

In short, the V S Clark school of thought believes the evidence indicates that the effects of the war were selective and uneven. Subsequently an uncertain environment for industrial expansion was created.

134. Clark, History of Manufactures (Vol. II) (1928:32-36); Engelbourg, "The Economic Impact of the Civil War on Manufacturing Enterprise" (1979:159); & Fite, Social & Industrial Conditions (1963:93)

135. Clark, "Manufacturing Development" (1967:63-64)

136. IBID:61

137. Engelbourg, "The Economic Impact of the Civil War on Manufacturing Enterprise" (1979:158-159)

Did the industrial environment retard military innovation? Indications are that even if one could prove that the Civil War stimulated industrial growth, there still appears to be no substantial link to the promotion of military technical change. Innovation occurred but was never aided as an overall activity by the industrial conditions. Separate and individual innovative enterprises were encouraged by industrial factors, such as large small-arms factories or nitre works, but these were generally exceptions.

Industry, when it did undertake military production, preferred known technical entities with commercial markets and with the greatest capacity to take up productive slack without a large capital outlay.

How, if at all, did specific industries promote technical change? Influence exerted by industries on technical change had no clear pattern. Influence was not related to size, resources, or apparent capacity to undertake innovation. The iron and steel industry in the North stands as one such example of how an industry could adhere to traditional products. Industries such as small-arms, clothing, and naval engineering were more able to make innovative contributions, but did not always promote the best-developed technical advances.

Two general rules of influence can be suggested, however. First, commercial advantage was the main inducement to promote innovations as well as to adhering to older technology. Second, whilst the impact of industries' intrinsic technical and procedural developments held an uncertain relationship to industrial growth and therefore profits, industries were more prone to adapt new technology to military production which offered securer returns.(138)

The influence exerted by industries on specific technical innovations was mixed. In general, had they supported good innovations and had government demand or military contracts offered worthwhile commercial returns for industries' promotion of these innovations, then more technical changes would have been promoted.

Did any link between the industrial environment and the general pattern of military technology change emerge? Because military technical innovations did not have their best designs promoted, the resulting weapons produced give only a shallow picture of all the advances actually made in the Civil War. This was not solely the fault of industry. The time involved in developing radically different designs, winning official support, and re-machining factories, weighed heavily against innovators immediately trying to secure commercial contracts.(139)

138. J.B. Rac, "The 'Know-How' Tradition: Technology in American History", *Technology & Culture* (Vol.1[1], Summer 1959-1960:145)

139. Davis, *Arming The Union* (1973:87)

As there existed no systematic adoption of new military innovations, industry in turn concentrated its resources on known commercial technology. To conservative private industries there seemed no reason to divert resources from traditional products or to expend enormous amounts of capital on developing products that had no guaranteed market. This seemed even more logical if the Federal Government continued to expand production from its own factories to meet its core military needs.

With the loss of pre-war markets, an excess of productive capacity over demand in major industries, and secure profits from selling existing weaponry, industry had little incentive to promote military technical change. When it did occur, change was incremental, based on the lowest risk options utilising existing production resources that could also be sold to defined military markets.

5.3 Social Environment

Although much has been written on the social dimensions to technological development, this section seeks to identify the chief areas where the social environment impacted on technical developments. Rather than make unsubstantiated generalizations, the significance of these areas will often not be fully apparent until the ensuing two chapters examine these areas in the specific context of an innovation.

A study of the Civil War social environment within which technology change was occurring can illuminate how society influenced technical innovations and was itself in turn affected by these changes.(140)

(A) Societal Attitudes

Societal attitudes play an important role, not only in promoting specific innovations but in generally producing an environment where technological change may be encouraged.

Prior to the Civil War, American history had emphasised the practical know-how approach to technological change.(141) The emphasis on inventions and inventors had usually encouraged social attitudes to applaud entrepreneurs and entrepreneurial abilities.(142) By the mid-1800s these attitudes had become in America, a distinct quality of "machine consciousness".(143)

Entering the Civil War, American society generally had a favourable attitude towards innovation, industrial expansion, practical skills, and engineering of ingenious

140. Habakkuk, *American & British Technology* (1962:182)

141. Rac, "The 'Know-How' Tradition: Technology in American History" (1959-60:145)

142. Habakkuk, *American & British Technology* (1962:111-112)

143. IBID:77; & Sawyer, "The Social Basis of the American System of Manufacturing" (1954:367)

mechanical devices. Although it was not always expressed in terms of demand for new products, society did sustain the development and use of new technical products.

The burgeoning industrial revolution through the 1840s and 1850s produced technological change with particular characteristics: either discrete changes to technology that produced a novel innovation without apparent antecedents or numerous small alterations to existing technology that provided a cumulative basis for wider technological change.(144)

How the economy affected military technological development, has been plagued by unresolved debates. It has been suggested that consumer demand was from 1857 until 1865 one of the major instigators of business development. As well as satisfying consumer demand in the North, developments in soap, kerosene, clothing, and mass-produced products were also utilised by the military. Although no one denies that the war stimulated different business opportunities,(145) the role societal factors played in sustaining production is far from clear.(146)

What is ascertainable is that through the war, the North and South evolved industrial systems that were diametrically opposed. Denis Brogan has suggested that the Civil War was an economic conflict between different economic systems.(147) If this is so, then the industrial-based Northern society was victor over the agrarian South. Yet while the North attained superiority through often-dubious industrial developments, the South never possessed the infrastructure, resources, or capacity, to sustain a war that from 1863 was a war of attrition.

While consumer demand may have increased Northern industries' profits and sustained other product development, it cannot be upheld that different social attitudes markedly influenced the course of military technical change or precipitated the level of industrialisation necessary to win the war.

(B) The Role of Science

One of the major factors influencing military technical change spawned by social attitudes is science. Society in America had always encouraged applied sciences, which not only confirmed the importance of science in society, but encouraged its role in everyday technological developments.(148)

144. N. Rosenberg, Technology and American Economic Growth (New York, Harper Torchbooks, 1972:17)

145. Habakkuk, American & British Technology (1962:1)

146. Smith, "Military Entrepreneurship" (1981:95)

147. Brogan, "The Debate on the American Civil War" (1963:220)

148. Rose & Rose, Science & Society (1970:240)

The Civil War saw the role of science leap ahead. Governments came to realise its importance not only in social development but in the war itself.(149) The promotion of practical research and the trial-and-error pragmatic way of innovation were further expanded by the recognition of the role science could play in sustaining the technological developments associated with the new industrial age.

The incorporation into societal attitudes and actions of scientific development, introduced an important phase of history. During this period, which ended with the First World War, there arose an awareness of the need for individual efforts to be co-ordinated and for practical or applied research to be backed with pure research efforts.

What the Civil War period introduced into American history was a period where "big science"(150) could be seen to expand on the research and development previous generations had created. This phase of science is noted for feeding off the scientific revolution, so broadening the industrial revolution and forever removing innovation from being the precinct only of entrepreneurial technologists.(151)

Science played an important role in the Civil War. It increased technical effort and gave an insight into how important discoveries in pure research were in expanding applied research work. Through the actions of individuals in the National Academy of Sciences, Northern technological development was systematically exposed to new ideas in photography, navigation, armour on ironclads, ballistics, explosives, and other areas of endeavour.

The role of science in Civil War technological change was encouraged by social attitudes that supported development. Despite understanding of the role of science still being at a very embryonic stage, by the war's end, science was positively addressing technical problems facing innovations.

(C) Labour

The development of the "machine consciousness" in nineteenth century America can largely be attributed to industry's search for labour-saving devices. Corresponding with the drive to save labour was the emergence of a factory system which adopted mechanised production as a means of overcoming shortages in labour and pushing down high wages.(152)

149. IBID:21

150. D.J. De Solla-Price, Little Science, Big Science (New York, Columbia University Press, 1963:106-112)

151. Smith, "Military Entrepreneurship" (1981:95)

152. Habakkuk, American & British Technology (1962:Chapter 1)

The Civil War caused further tightening of the labour market as labourers became soldiers. Industry was forced to try and attract labour away from agriculture and competing industrial sectors by offering higher wages.(153) This resulted in price increases to offset wage costs and produced an inflexible labour market where labour lacked inter-sectorial mobility and had a narrow skill level, and where workers' militant bargaining power was confirmed.(154)

Attempts to circumvent these problems greatly promoted industrial innovation. Mechanisation increased capital intensity in industry,(155) which in turn made surplus capital from profits available, for release into expanding industries. This is often considered as the impetus behind what W W Rostow calls the "take-off" point in American economic development.

The capital generated after the mechanisation spurred growth of 1850 to 1857, was mostly held in savings during the subsequent 1857 to 1860 recession. When the railways and transport industries began to boom, the saved capital was fed into an American business resurgence.(156)

Labour shortages accelerated the introduction of steam-driven machinery such as machine tools into the small-arms industry and the Arkwright waterframe and sewing machines into the textile industry. Conversely, however, where labour existed in some numbers and a diffusion of capital could proceed at a constant wage, there:

... was no inducement to replace existing equipment unless the new equipment yielded a higher rate of profit on the value of the old and new machinery together.(157)

This helps explain why some excellent innovations that were capable of radically altering Civil War production, like the Bessemer conversion process, never replaced older less technically advanced machinery.

Another influence upon industry was through management. Both as a part of industry's labour force and as a controlling influence over labour, the essential inadequacies of Civil War management deeply affected technical advances.

Management during the war generally failed to comprehend technical innovation. It lacked both the ability to assess innovations and to put forward the benefits of

153. Up to 30 per cent more than similar industries in the United Kingdom. IBID:76

154. IBID:70-77; & Fite, Social & Industrial Conditions (1963:205-207)

155. Habakkuk, American & British Technology (1962:76)

156. IBID:77; & D.C. North, T.L. Anderson & P.J. Hill, Growth & Welfare in the American Past: A New Economic History (New Jersey, Prentice-Hall, 1983:103-106)

157. Habakkuk, American & British Technology (1962:59)

technological ideas. Coupled with this failing was a lack of understanding of how innovation could assist a company to achieve its goals and objectives.

Managers lacked the concept of market competition to help determine how they introduced structural changes and personnel policies, or utilised machinery to gain maximum returns. Yet there were enough corporate exceptions in the Civil War era, to indicate that management techniques were changing. Railroad companies began to produce skilled, well educated managers, while companies such as Du Pont and Winchester were able to use technological development to become leaders in newly created markets.(158)

Lack of innovative spirit in management and the existence of labour constraints meant there was little support for industrial innovation during the Civil War, so industrial innovation was either limited to a few select, forward-looking companies with guaranteed profits or to improvements induced by the expansion of the machine-tool industry. The net impact on military technical innovation was mostly felt in the production technology used by small-arms companies and in the limitation of extensive development and production changes to commercially viable technology.

(D) Individuals and the Civil War

The conduct of warfare in one's own territory greatly affects all of society and very few Americans could escape the impact the American Civil War produced. The South was, in particular, to have the scars of the war left on all its citizenry. The blockade of the South, the strategic importance of townships, the continuous attempts to produce the materials of war, the supply of front-line needs, and the guerilla war conducted by both sides, removed the clear line between soldiers and citizens.

The struggle confirmed the economic and geopolitical divisions between North and South. The Confederacy was proud of its agricultural heritage and its martial prowess.(159) In the North, the industrial age and the drive for broader personal horizons lent a framework to a diversity of cultures and people. Neither side, though, could have been prepared for the long martial struggle or the attrition of men, material and societies that the destruction of ante-bellum society would bring.(160)

158. North (et al), Growth & Welfare (1983:106)

159. M. Beloff, "Great Britain & the American Civil War", Historical Revision No.CXVIII: History (Vol.37, 1959:46)

160. North (et al), Growth & Welfare (1983:88)

The Southern armies mobilized some 1,200,000 white men into service and experienced some 350,000 casualties.(161) When one considers that the population of the south was only some 5,500,000 whites and 3,500,000 blacks in eleven states, then the impact of the war can be appreciated.(162) As fierce as the political passions ran, the North never could produce as systematic a level of conscription.

Thus while the Confederates conscripted their men to fight for a cause that paradoxically was to preserve states' and individual's rights from centralised government,(163) the North met these forces only with some 2,100,000 men.(164) This included men counted separately for each re-enrolment, re-enlisted wounded and discrepancies in records and official lists. This was from a Northern population which had about 22 million whites and 500,000 blacks.(165)

The North had the capacity to draw from at least three times the number of Confederate men of military age in the 15-40 age group.(166) These resources were never fully drawn on as many Northern males felt no compulsion to join the armed struggle. This was despite powerful opinions in favour of the war, such as that of General W T Sherman who believed that:

...in 1861-5 we fought a holy war, with absolute right on our side, with pure patriotism, with reasonable skill, and that we achieved a result which enabled the United States of America to resume her glorious career in the interests of all mankind...(167)

Such opinions seem to differ from those who rioted in the Draft Riots of July 1863.(168) There were a swift and violent reactions against the "Act for Enrolling and Calling Out the National Forces, and for Other Purposes" and the appointment of an Enrolment Board in March 1863.

Many soldiers were also mercenaries, or men who were paid by draftees to fight in their stead. "Patriots" were earning nearly \$300 for three-year enlistments.(169) This only matched what agricultural and industrial workers could hope to earn in the same period of employment.

161. McPherson, Ordeal By Fire (1982:181); & P. Griffith, Rally Once Again (Wiltshire, Crowood Press, 1987:95)

162. L.C.F. Turner, "The Grand Strategy of the Civil War", Australian Journal of Politics & History (Vol.26[1] 1980:57)

163. McPherson, Ordeal By Fire (1982:181)

164. IBID

165. Turner, "The Grand Strategy of the Civil War" (1980:57); and see A. Nevins, The War for the Union (Vol.I) "The Improvised War 1861-62" (New York, Charles Scribners, 1959:424-425) for a discussion of the Northern & Southern resources of 1860.

166. Nevins, The War for the Union (Vol.I) (1959:425)

167. Sherman, "The Grand Strategy of the Rebellion" (1888:582)

168. Shannon, Organization & Administration (Vol.I) (1965:299)

169. IBID:63

Some of the developments affecting individuals were to have even more profound influences. The use of new technology such as railroads and the telegraph brought people closer to the war, which had a notable effect. Despite the consolidation of statesmens' and generals' roles, Civil War military leaders were plagued by political interference. Soldiers were, therefore, in many ways evolving as politicians' chess pieces, rather than the generals'.(170)

As control could be exerted over far-flung battlefields, the distinction between executive power and military initiatives became blurred. For soldiers, and later for American society as these soldiers returned to their normal lives, there was born a deep mistrust of executive control of strategy for political rather than tactical goals.

As wounded returned home, as the press published the horror and euphoria of warfare only hours after it occurred, American society was forced to confront the legacies of this destructive war. It was not just soldiers, sailors, negroes and politicians who were involved in the war. Any examination of the quantity of literature on the Civil War shows that the profound impact of the war reverberated through American history.

The result of such fundamental changes was important for the way the technological environment evolved. In the North, the confused attitude to the war produced a stifling environment. Those seeking to direct manpower, financial resources, and technical development towards maximum war effort were confronted with a society not totally convinced that such reactions were desirable.

Individual labourers, industrialists, politicians, and other fortunate people were often advantaged by the war.(171) Their rewards only served to taint the loss and sacrifice made by soldiers at the front. Put simply, Northern society was confused over the merit of the armed struggle.

Unlike the North, Southerners were more likely to perceive themselves as fighting for survival. Most soldiers and citizens were faced with hardships, and few could not see the necessity for using all available weapons to assist their cause. Thus was born a spirit of co-operation and joint support that spawned ingenuity and desperate efforts to promote military innovation. Despite the trials and challenges to the spirit of confederation, individuals in the south did strive to overcome the perceived aggression of the Union.

170. Wolseley (Viscount), "An English View of the Civil War", North American Review (Part II) (Vol.149[392], July 1889:36) & (Part III) (Vol.149[393], August 1889:165); & M.C. Meigs, "On the Conduct of the Civil War", American Historical Review (Vol.26[2], January 1921:290-297)

171. Engelbourg, "The Economic Impact of the Civil War on Manufacturing Enterprise" (1979:158)

In the South, individual attitudes saw the war as a forlorn struggle against impossible odds. In such an environment, military technical innovation offered some hope. In the North the war increasingly became a hopeless moral dilemma that technical innovation in military technology was often perceived to be reinforcing.

(E) Economic Conditions

Economic factors affected the social environment and were intrinsically a part of that environment. It is because of this confusing duplicity that a study of economic conditions in the Civil War is very challenging.(172) Opinions on the topic vary greatly. Therefore, this section will simply outline the important points relating to the factors of production, structural supports, and techniques that affected the acceptance of technology.(173)

Innovation in products and processes had throughout the course of the war increasingly influenced the adaptation and adjustment in capital goods industries as well as helping to create new technical requirements. These alterations influenced the factors of production available to other industries. For instance, the small-arms industry was:

...instrumental in the development of the whole array of tools and accessories upon which large scale production of precision metal parts is dependent; jigs (originally employed for drilling and hand filling), fixtures, taps and gauges, and systematic development of die-forging techniques.(174)

In the agricultural industry and in transport, wartime growth and prosperity resulted in a reduction in prices that stimulated improvements in equipment.(175)

In the flow-on from technical changes, some industries lacked the structural integrity to reinforce their activities and expand their prosperity. This structural inflexibility, therefore, also created an economic system that only slowly geared up to exploit business opportunity.

The period of economic growth, prior to the realization of opportunity, is also marked as a period where technical gestation was occurring.

After an innovation had been developed, but before it was produced, a business's ability to profit from resulting opportunities affected the future course technical development

172. O'Brien, Economic Effects (1988:9); & C. Goldin & F. Lewis, "The Economic Cost of the American Civil War: Estimates & Implications", The Journal of Economic History (Vol.35, June 1975:299-326)

173. Rosenberg, Technology and American Economic Growth (1972:60)

174. Filch Quoted in Rosenberg, "Technological Change in the Machine Tool Industry 1840-1910" (1963:427-428)

175. Fite, Social & Industrial Conditions (1963:77)

might take.(176) It was in this developmental stage that business realized the economic potential, of exploiting an innovation that could often reshape technological change.

Economic adjustments in the Civil War were occurring in a manner that reflected this gestation scenario. In the railroad industry, expansion was inducing adjustments as capital expansion stimulated ancillary industry development. Reduced transport costs, the development of corporate organisations, and the relocation of economic activities, all mark the growth of the economic importance of the railroads.(177)

Similarly, it is possible to establish that the ASM was laying the groundwork and sustaining conditions for industrial growth.(178) In the small-arms industry and in the industries that had slack productive capacity or new capacity created by the Civil War, these conditions induced economic expansion.(179)

The effect of economic conditions upon society was to encourage the use of new techniques to produce both old and new products. Nevertheless, there existed a lag between technical changes and vital economic and institutional supports necessary to immediately exploit technical changes. By the war's end, these economic factors had been realised and their reciprocal impact on the environment was established.

5.4 Military Technological Change as an Environmental Function

The prevailing general environmental factors surrounding Civil War military technological change were not wholly supportive of innovative efforts or their rapid adoption.

Government could neither control nor understand what was happening, not having already understood technological risks and ways of making the new happen, and so it took the much greater risk of being surprised by what did happen. It was surprised by war demands for weapons and had to satisfy these short-term needs with the available low-risk technology.

However, the environment for military technological change was by no means totally unsupportive. The increased influence of central government and the existing industrial factors certainly influenced innovative efforts. Likewise, the prevailing social attitudes and the effect war produced on individuals generally was not antagonistic to technological change. The largest single problem facing expansion of military

176. Rosenberg, "Technological Change in the Machine Tool Industry 1840-1910" (1963:420)

177. North (et al), *Growth & Welfare* (1983:101)

178. Sawyer, "The Social Basis of the American System of Manufacturing" (1954:379)

179. Engerman, "Economic Impact" (1966:180 & 184)

innovation was that there existed no formalised general framework within which to encourage specific innovations.

Government did produce cogent general policies that could assist military technical innovations. Intervention by way of public enterprises, patents, contractual procurement, and limited scientific assistance did provide more co-ordination of technical endeavours. Industry also attempted to promote innovations that were commercially viable. By 1863, in both the North and South, the general society was struggling under the moral and economic burden imposed by a war that seemed to have no 'noble' end.

Environmental factors, with some exceptions, seem to have generally been unable to positively influence the creation of institutional and attitudinal supports, necessary to nurture military innovation.

CHAPTER 6: ADMINISTRATIVE CONSTRAINTS ON MILITARY TECHNOLOGICAL INNOVATION

Whilst this thesis has identified key technical changes, and sought to link technical and non-technical factors together in the study of technology, the study is still far from complete. The study of general environmental conditions has not fully explored the particular conditions that influenced the administration of military technological change. To cover this omission it is necessary to study those institutional factors that constrain innovation.

As we have seen in the last chapter, industrial effort was isolated by the philosophy of *laissez faire*. There was an absence of a co-ordinated innovation process linked through political control to military needs. At the beginning of the war the North was almost totally devoid of any existing governmental framework by which to sponsor military technological development, let alone identify and promote those innovations that would become necessary during a future conflict. The adoption of military technology was, therefore, left to those whose interests the innovations were supposed to serve: the military organizations.

Simply to indicate that the environmental constraints added to the malaise of military technological development, in no way assists our understanding of the specific factors that inhibited military bureaucrats' adoption of new technology. We have not for instance addressed why the North was better able to adopt new technology after 1863, but did not deploy innovations in times of critical need prior to that date.

As greater numbers of new weapons were introduced into military arsenals, they not only transformed warfare, they also challenged traditional thoughts and practices.⁽¹⁾ The USS Monitor, CSS Merrimac, the Henry repeating rifle, the Gatling Gun, and torpedo related technology, all clearly demonstrated their potential as military tools. Yet there arose problems with administrative delays in the assessment of the role these new technologies could have in the war.

It is the aim of this chapter to more fully comprehend the organizational problems and administrative factors that collectively served to hinder the nurturing of wartime innovations. The study will concentrate on the Northern administration but will look at the South to highlight important differences.

1. P.J. Parish, The American Civil War (London, Eyre Methuen, 1975:129)

6.1 Indicators of Malaise

At the outbreak of the American Civil War there were few advances in military technology despite the significant developments instigated by the on-going industrial revolution. Considering that the industrial revolution was well established by 1861, and there occurred a myriad of military technological changes during the Civil War period, why is there such debate over the inability of Civil War technologists to further extend the lessons derived from existing technological advances?

After their defeat at the first battle of Bull Run early in the war, the North was confronted with the fact that the war was not going to be resolved quickly. Far from mobilizing its industrial resources to produce future military tools, the Union was struggling to provide an adequate administrative framework for co-ordinating the war effort. The creation of an effective structure for mobilizing men and arming them preoccupied the military and civil bureaucrats of 1861.(2) Even in today's terms an attempt to immediately increase a standing army tenfold, would raise enormous problems. Within the existing infrastructure and wide administrative expanse of America in 1861, the task was indeed formidable.(3)

The administration of the Civil War progressed through a confused adolescence until 1863.(4) In both the North and the South many of the components necessary to build an effective war administration existed, but these were sketchy and designed for a US Army of 16,000, not the mass armies of the Civil War.(5) Growth to any semblance of consolidated control was slow and inadequacies in organizational practices soon became evident.

Despite the administrative inefficiencies on both warring sides, the opposing War and Naval Departments were headed by strong, skilled individuals. These included Secretaries such as Gideon Wells in the US Navy Department, Edward Stanton in the US War Department, Salmon Chase in the US Treasury, and their counterparts; Stephen Mallory of the CS Navy Department, James Seddon of the CS War Department, and Christopher Memminger, Secretary of the CS Treasury. These men were responsible for co-ordinating administrative changes that were from 1863 to

2. J.G. Nicolay & J. Hay, "Abraham Lincoln: A History. The Call to Arms", The Century Magazine, (Vol.35[5], March 1888:721); & J.M. McPherson, Ordeal By Fire: The Civil War & Reconstruction (New York, Alfred A. Knopf, 1982:181)

3. A. Nevins "1861: A Primitive Administration" in W.R. Brock (ed), The Civil War (New York, Harper & Row, 1969:133)

4. IBID:137-146)

5. IBID:133

create organisations totally different from the agencies that served their apprenticeships in 1861.(6)

Even with the evolution in administrative practices, the large war organisations became unwieldy morasses of bureaucratic practices. The urgency of wartime administration compounded the incapacity of organisational designs or management to control the operations of these new bodies. In particular, the War Department of the North, while concentrating on running land conflict, was not able to properly conduct other important operations.

One of the Northern War Department's fundamental mistakes was its failure to co-ordinate changes to military technology.(7) Holding the greater industrial base, with a capacity to undertake military technical development, the War Department in the North failed to create the necessary institutional supports for innovative endeavour.

In the South the War Department's inability to control military innovative effort accentuated problems with managing the allocation of scarce resources.(8)

Ludwell Johnson summarised the malaise in military administration of new technology when he wrote:

In the welter of conflicting pressure groups and political factions it was indeed difficult for the Federal government to bring to bear its enormous material and numerical supremacy. Therein lies the key to the great mystery of the war, which is not only why the South lost but why the North took so long to win.(9)

6.2 Exploitation of Innovations by Northern Military Organisations

For the duration of the Civil War it was left to the individual military organisations to promote military technical innovation to the best of their ability. Regardless of a new weapons' potential, the degree of political patronage, or its synergy with existing arms and tactics, its fate more often than not depended more on the organization's administrative ability than the weapon's potential.(10)

It is possible to identify how the different administration of new technology by Northern military organizations affected the deployment of technology. The Ordnance Bureau

6. IBID:146

7. F.A. Shannon, The Organization & Administration of the Union Army (Vol.1) (Massachusetts, Peter Smith, 1965:108)

8. IBID:108

9. Johnson, "Civil War Military History" (1971:130)

10. D.A. Armstrong identifies bureaucracy as playing a the critical role in introducing new weapons into military doctrine, Bullets & Bureaucrats (Westport, Greenwood Press, 1982:xiv)

will be examined to highlight the resistance to innovations from those within the bureau. An examination of the Quartermaster Department, in particular, will be used to identify the wider implications of why a powerful organization with its established priorities could prevent the adoption or administration of new technology. This example will extend into an examination of the Military Railroad Department, the Signals Corps, Military Telegraph Corps, and Balloon Corps. These agencies were specifically given the responsibility to administer new technology. The success of their operations was particularly dependant on the support of established military organizations such as the Quartermaster's Department.

An examination of the Medical Department and the Corps of Engineers will also be made in order to discover how more established military organizations were able to meet wartime operational needs whilst responding to innovations that would improve the performance of the Corps' core function.

A study of the United States Ordnance Bureau (USOB) is perhaps the best starting point for a discussion of the administration's ability to exploit innovations. The USOB and its Chief from 23 April 1861 until 15 September 1863, Colonel (later Brigadier General) James W Ripley, have inspired much academic ridicule for their failure to adopt new weapons.(11)

Much blame has been laid at General Ripley's feet for his failure to understand the importance of new technology, and furthermore for his failure to adopt innovations at a greater pace. This criticism of Ripley encompass details that illustrate the importance of understanding military technological change as a wider environmental function.

The plethora of small arms designs being produced in limited quantities, and then forced on the US Army, confirmed for the Union Generals that the USOB testing and introduction program was being circumvented. For field commanders their worst fear came not from having to field test weapons of unknown reliability, but without standardized calibre or performance bench-marks, unsatisfactory weapons were being put into production and issued to troops. This meant that not only were most innovations occurring without consideration of the existing technology in service, but there was no regard given for their ultimate technical merit as combat weapons.(12)

11. W.R. Brock, Conflict & Transformation: The United States 1844-1877 (London, Penguin, 1978:285)

12. W. Ripley, Artillery & Ammunition of the Civil War (New York, Van Nostrand Reinhold, 1970:99 & 105)

Coggins wrote that throughout the war:

It is hard to understand why the Federal Government never made a determined effort to arm the troops with breech-loaders. There was no question as to their effectiveness, and the men were so anxious to have them that in many cases, companies would save their small pay and purchase the arms themselves.(13)

Such strict analysis of the physical technologies has perpetuated perplexing questions about why the BLR technological change was frustrated. However, these questions should be understood in the context of the conditions actually confronting the USOB at the beginning of the Civil War.

When on 15 April 1861 President Lincoln called for 75,000 volunteers, he far surpassed the existing pre-war army of 16,000 soldiers or the army of 21,000 raised for the Mexican War of 1846 to 1848.(14) As the army grew from 1861 until the war's end, problems of organising and equipping these men became more acute.(15) These problems dominated attempts to build an Ordnance Bureau that could cope with the wartime demands placed on it.

The expansion in the army was matched by only very minor growth in Ordnance Bureau personnel, and a hopelessly inadequate growth in resources. The breech-loading arms were clearly superior to muzzle-loaders for infantry operations, especially the cavalry.(16) Given that General Ripley as Chief of the USOB was personally responsible for arming the largest army ever assembled in the industrial age, the introduction of a number of different types of BLR represented an uncertain option. These weapons were also at least a third more expensive than the Springfield 1855 Model, had a variety of ammunition types and calibres, unproven capacity for machined interchangeable parts (in an age when this was considered a great technical achievement), and questionable production schedules run by private entrepreneurs. On existing tactical requirements these weapons were considered unsatisfactory to use with a bayonet attached, were too heavy, and encouraged too much ammunition wastage.(17)

The immense small-arms shortfall at the beginning of the war override any other pressing arms-problems affecting the Union forces. Despite the availability of local manufacturing, the Northern government, through the Ordnance Bureau, sent agents overseas to purchase weapons. By 30 June 1862, 738,000 overseas muskets and rifles

13. J. Coggins, *Arms & Equipment of the Civil War* (New York, Double Day, 1962:28)

14. Nicolay & Hay, "Abraham Lincoln" (March 1888:721)

15. IBID:721

16. J.M. McPherson, *Ordeal By Fire: The Civil War & Reconstruction* (New York, Alfred A. Knopf, 1982:141)

17. J.K. Mahon, "Civil War Infantry Assault Tactics", *Military Affairs* (Vol.25[2], Summer 1961:58)

had been purchased.(18) Government enterprises and contracts in the same period concentrated on the production of Springfield percussion muzzle-loaders. At a cost of only 16 dollars from a government factory and 20 dollars from a private firm the Springfield was a tried, cheap, and reliable weapon.(19)

The Union's complete failure to promote breech-loaders despite their obvious potential is still difficult to comprehend. It seems certain that General Ripley was deeply committed to the Model 1855 Springfield MLR and considered it superior to breech-loaders.

As he had sat on the committee responsible for its design and introduction in 1855, General Ripley was biased towards the Springfield. Yet his dislike for rifled arms, and in particular, his reluctance to adopt breech-loaders, goes much deeper. He was already confronted with the problem of having to provide enormous amounts of ammunition for the 0.58 calibre Springfield, to which was added the immense confusion of calibres as the foreign weapons reached the troops. Breech-loaders and repeating rifles exacerbated existing administrative problems.(20)

General Ripley himself best describes his position:

A great evil now specially prevalent in regard to arms for the military service is the vast variety of the new inventions, each having, of course, its advocates, insisting on the superiority of his favourite arm over all others and urging its adoption by the Government. The influence these exercised has already introduced into the service many kinds and calibres of arms, some, in my opinion, unfit for use as military weapons, and none as good as the US Musket [1855 Springfield], producing confusion in the manufacture, the issue, and the use of ammunition, and very injurious to the efficiency of troops. This evil can only be stopped by positively refusing to answer any requisitions for or propositions to sell new and untried arms, and steadily adhering to the *rule of uniformity* of arms for all troops of the same kind, such as cavalry, artillery, infantry.(21)

The modern critics who have often labelled him "Ripley Van Winkle", should consider this statement from General Ripley. His actions imposed limitations on the introduction of arms that would have added to the declining ability of the USOB to standardize not only ammunition but also interchangeable parts between arms.

Wary of poor designs, the USOB felt that the adoption of tough standards would restrict the introduction of BLR designs. Opposition to the Henry repeating rifle was

18. Shannon, Organization & Administration (1965:118)

19. IBID:120

20. National Rifle Association of America, Civil War Small Arms, (Washington, NRAA, 1960:27)

21. Ripley July 11, 1861 quoted in Bruce, Lincoln & the Tools of War (1973:69), emphasis added.

focussed on the claims that it fired too much ammunition and had too many moving parts. The design certainly proved to be unnecessarily prone to stress breakage of delicately machined parts, and the ammunition held in a magazine under the barrel was exposed to potentially dangerous hard knocks.(22)

Under General Ripley the Ordnance Bureau felt vindicated in its belief that all weapons should be of a robust design, should take a standard bayonet, and conform to the 0.58 calibre type muzzle-loading ammunition. The Ordnance Bureau was thus able to prevent the diversion of its war effort towards innovative designs that were both expensive and more difficult for untrained soldiers to use.(23) These attitudes were further consolidated by a USOB wartime philosophy that saw the private production of all designs other than the Springfield as only 'stop-gap' measures until the government armories could meet military demand.(24)

General Ripley confronted the confusion over arms introduction by belligerently refusing to consider any innovative designs. It was not until, by the order of President Lincoln, he was replaced by General George D Ramsay that new designs received more balanced consideration.(25) The new Ordnance Bureau direction from September 1863 came to reflect Ramsay's belief that:

Repeating arms are the greatest favourite in the Army and could they be supplied in quantities to meet all requisitions, I am sure no other arm would be used.(26)

Despite Ripley's fervent adherence to his decision to deny small-arms technological change, the impact of these new weapons in the war was considerable.(27) Soldiers and officers alike, State regiments, and whole troops of cavalry, had by official or unofficial means secured breech-loading and repeating rifles.(28)

The administrative reforms of 1863 reflected an acceptance of the importance small-arms innovations had in the conduct of the war. Once reformed, the organisation became responsible for introducing the very designs that the earlier Ordnance Bureau

22. F. Wilkinson, The World's Great Guns (London, Hamlyn, 1973:173)

23. C.E. Fuller & R.D. Steuart, Firearms of the Confederacy (West Virginia, Standard, 1944:6); & D.F. Butler, United States Firearms (New York, Winchester Press, 1971:100)

24. General Ramsey in Official Records "The War of the Rebellion, A Compilation of the Official Records of the Union & Confederate Armies" (Series 3, Vol.4) (Washington D.C., Government Printing Office, 1900:590)

25. Ramsey was in fact supported BLR that used metallic cartridges see, Davis, Arming The Union (1973:139)

26. Quoted in Coggins, Arms & Equipment (1962:28)

27. Some tactical changes were occurring despite the limited introduction of rifled ordnance see A. Nevins, The War for the Union (Vol.I) "The Improvised War 1861-62" (New York, Charles Scribners, 1959:364); & J. Luvaas, The Military Legacy of the Civil War (Chicago, Chicago University Press, 1959:64)

28. J. Ellis, The Social History of the Machine Gun (London, Cresset Library, 1975:25)

had only reluctantly adopted or had rejected.(29) By 1863, then, small-arms technology changes had been consolidated through the co-ordination of innovative effort in areas where wartime experience had suggested greatest promise.

The year 1864 saw the introduction of 33,657 repeating rifles, mostly of the combat tried Spencer design, and 15,051 single shot breech-loaders using copper self-contained ammunition. Orders were also placed for 78,100 repeating rifles and 11,850 more breech-loading rifles to be supplied by August 1865.(30) Not only was industrial production stimulated but innovative endeavour became concentrated upon a few of the best designs.

In retrospect we can see that the significant benefit of these innovations defied the dire predictions of General Ripley, yet they did not destroy the system he had sought to preserve; in 1866 the US Army stopped issuing repeating rifles. Instead the government concentrated on producing a BLR version of the Springfield Model 1855 within their armories.(31)

While the USOB appears to be an inhibitor of technological change because of its administrative decisions, not all US Army Corps were able to recognize the potential of some innovations. Other Corps had no capacity to promote military technological change because important discoveries in scientific and technical knowledge were still unknown during the war. The examination of the US Army Medical Corps supports this later situation, while the Quartermaster Corps is an interesting contrast in its wartime failure to promote technology with military applications.

Faced with massive numbers of casualties, disease, wounds and the inadequacy of medical knowledge, the whole practice of medical care came under review.(32) The need for medical reform was accelerated by the war; devastating diseases, the impact new weapons had on massed armies, and the need to quickly remove wounded to hospitals, all instigated change.(33)

In the introduction of medical technological change, the USAMC had a clear charter to amend the desperately inadequate medical system. Unfortunately, the USAMC had only limited success in promoting new technology. During the war contemporary

29. Armstrong, Bullets and Bureaucrats (1982:42)

30. Shannon, Organization & Administration (1965:141)

31. The Springfield M1866 .50-70-450 Centre-Fire Calibre Rifle. This weapon was in reality a design that utilized technical advances but on a converted frame of the earlier 1855 Springfield Rifle. Butler, United States Firearms (1971:180-182 & 184)

32. I.B. Cohen, "Science & the Civil War", Technology Review (Vol.48, 1946:167)

33. A. Hunter-Dupree, Science in the Federal Government (Massachusetts, Harvard University Press, 1957:128); & S. Zuckerman, Scientists & War (London, Scientific Book Club, 1966:33)

medicine was given a prime opportunity to apply new techniques, and for amending formerly inviolable traditional practices that could not handle wounds inflicted on the battlefield.

The institutions set up during the war to initiate these reforms were the US Medical Department and the Sanitary Commission. The US Navy also maintained medical staff to treat its wounded.⁽³⁴⁾ All organizations were successful in introducing gradual improvements to pre-war medical practices, but no significant advances were made through the military's use of medical technology or scientific knowledge.

The ability of these organisations to promote medical reform through technical development was limited. Improvements in the treatment of battlefield wounded were mostly restricted to provision of ambulances, better hospitals, organised treatment, and minor improvements to surgical tools. Innovations in hygiene and sanitation were also mostly restricted to important improvements in existing tools and techniques.

Changes to the treatment of battlefield wounded were influenced by a number of ancillary factors. As with the USOB, the organization had to firstly adapt in order to handle the unprecedented number of wartime casualties that overburdened medical facilities. Once they had adapted their services to meet the demands placed on them, the North and South were able to function in a competent manner.

Although no precise figures of the numbers of wounded exist, at least 110,000 to 200,000 soldiers died of wounds received in the war.⁽³⁵⁾ However, between 360,000 and 560,000 soldiers died of other causes.⁽³⁶⁾ Of those who died of wounds, two trends are significant. Firstly, very few wounds were caused by bayonets, swords, or lances; secondly, most deaths occurred when massed formations attacked defended positions.⁽³⁷⁾ In some cases, when good defensive positions were attacked by infantry or cavalry, the attacking forces as shown in the war records lost up to seventy or even eighty per cent of their strength!⁽³⁸⁾ At this time 5 per cent was an average number of casualties and 40 per cent was considered extremely high.

34. H. Hattaway & A. Jones, "The War Board, The Basis of the United States First General Staff", Military Affairs (Vol.46[1], February 1982:5); & Hunter-Dupree, Science in the Federal Government (1957:128)

35. W.P. Kremer, 100 Great Battles of the Rebellion (New Jersey, Hoboken, 1906); H.S. Commager, M. Cunliff & M.A. Jones (eds), Illustrated History of the American Civil War (London, Orbis, 1976:265); C.B. Colby, Civil War Weapons (New York, Coward-McCann, 1962:4); & H. Joules (ed), Doctors' View of War (London, Allen & Unwin, 1938:20)

36. Commager (et al), Illustrated History of the American Civil War (1976:265); & Joules, Doctors' View of War (1938:20)

37. Kremer, 100 Great Battles of the Rebellion (1906:Introduction); & W. Millis, Armies & Men (London, Johnathan Cape, 1958:127)

38. McPherson, Ordeal By Fire (1982:193); W.F. Fox, "The Chances of Being Hit in Battle". The Century Magazine (Vol.36[1], May 1888:103)

The effect of these battlefield losses upon the USAMC was immediate and profound. Although in existence prior to the war, the USAMC was confronted with serious organisational limitations. The chief defect of the US Army's medical system was its early adherence to a strict regimental organisation.(39) This system was inflexible, and took no account of wider army needs. Confronted with its inability to control collection of a massive number of wounded, who needed prompt treatment, and given the rampant spread of disease, the Corps had to reorganise its services dramatically.

By end of the war the efforts of Surgeon General William A Hammond and the Medical Director of the Potomac Army, Dr Jonathan Letterman, had succeeded in strengthening field hospital systems and introducing field ambulances to each Corps.(40) Advances in carriage design produced ambulances that could more efficiently remove the wounded to hospital, and hospitals were reorganised and rebuilt to facilitate the more streamlined treatment of patient. Copying the Southern example, the North devised a hierarchical system of field hospitals, clearing stations, regimental and later army hospitals, and general hospitals.(41) Innovations were built into a system that saw the use of railroad hospital trains; the division of hospitals into special functions, with general hospitals having wards to care for each class of injury; and increasingly better classification, treatment, and nursing care for patients.(42)

The use of chloroform as an anaesthetic and morphine and opium as pain killers in operations became more extensive.(43) Neurological treatment and stomach and chest-wounds treatment were all significantly improved during the war.(44) Despite these advances wartime medical officers were ignorant of germs, sepsis, and the proper use of antiseptics.(45) Many wounded were, therefore, tragically lost to post-operative infections even though better surgical tools and techniques were in use. Accentuating this was the USAMC's continued inability to rapidly transport wounded or perform interim surgery in 'field hospitals' because the risk of death from infection had not been overcome. Located close to the front these 'field hospitals' usually did not represent more than a tent with an overworked 'medical assistant' performing surgery on those unable to survive without immediate attention.

39. Cohen, "Science & the Civil War" (1946:168)

40. IBID

41. H.H. Cunningham, Doctors in Grey: The Confederate Medical Service (Baton Rouge, Louisiana State University Press, Second Edition 1960:116)

42. IBID:Ch.4; G.W. Adams, Doctors in Blue: A Medical History of the Union Army in the Civil War (New York, Henry Schuman, 1952:Chapter 8 on "General Hospitals"); & W. Whitman, "Army Hospital & Cases", The Century Magazine, (Vol.36[6], October 1888:825-830)

43. Coggins, Arms & Equipment (1962:117)

44. Cohen, "Science & the Civil War" (1946:168-169)

45. Cunningham, Doctors in Grey (1960:231)

In the area of hygiene and sanitation, the story of military medicine had a more favourable conclusion although diseases such as typhoid, which claimed 35,000 Northern soldiers; scurvy with 30,000 recorded cases; epidemic jaundice, with 70,000 cases;(46) and other diseases like influenza, cholera, typhus, smallpox, and measles were the bane of contemporary soldiers.

The remedy for the greatest killer of soldiers, disease, grew out of the British sanitary body instituted in the Crimean War and its concept of preventive medicine. The North formed a Sanitary Commission, which was able to actively participate in camp hygiene, the transportation of wounded, hospital staffing, and the administration of new medical ideas. Through their efforts, improved tents, clothing, clearing of camp grounds, methods of cooking food, and better diet were instituted in many army corps.(47) These duties were carried out despite constant opposition from the formally established Medical Department.

Despite the volume of sick and wounded, and in spite of poor administration, innovation in practical areas was used to assist with ancillary reforms to the system of medical care. From this basis there evolved a more coherent medical system that improved the survival chances of a wounded soldier, and reduced the chances of the soldier falling ill to preventable diseases.

The United States Quartermaster Corps (USQMC), like the USAMC, stands as an example of an organisation that had its pre-war administrative function extended during the war beyond any preceding level. Unlike the USAMC, the Quartermaster organisation was considered a major part of the War Department and a central part of military operations. While the administrators of medicine and ordnance matters struggled to handle increased workload and to secure the resources necessary to perform its function, the USQMC, as an established Corps, was always in a better position to secure scarce resources.

The Chief of the USQMC, General Montgomery C Meigs, from 15 May 1861 until some twenty years later, had consolidated the organisation's military role and asserted its pre-eminent role in all high level military decisions.(48)

Alone of all the military service corps, the USQMC was an organisation with a solid power base, a strong administrative network, and the autonomy necessary to introduce

46. Joules, *Doctors' View of War* (1938:23, 34 & 64)

47. Adams, *Doctors in Blue* (1952:6-7)

48. Hattaway & Jones, "The War Board" (1982:2); & Nevins, "1861: A Primitive Administration" (1969:140)

military developments.(49) As one of the oldest and best established departments, USQMC had control of key functions such as provision of "quarters and transportation of the army; storage and transportation of all army supplies; army clothing; camp and garrison equipage; cavalry and artillery horses; fuel, forage and straw; material for bedding; and stationery." (50)

Overall, however, the USQMC was more concerned with consolidating its own operations and directly exerted very little positive influence over military technological change. However, the loss of Meigs' support for innovation could prove decisive. With his position of power in the military hierarchy, and the important controlling function performed by the USQMC, Meigs could ensure a new technological entity was, or was not deployed effectively.(51)

Unlike other service Corps that influenced technical changes by their adoption or rejection of a technological innovation, the USQMC was quite unique in its ability to produce far-reaching influences upon military technology. Rail use stands as an example of how endorsement by a powerful administrative body could further technology change.

Under Meigs' authority the USQMC extended its influence into many areas that impacted on innovative effort. It assumed responsibility for operations of balloons, ambulances, rail rolling-stock, fixed telegraph lines, and many of the personnel attached to these and other corps. Meigs' capacity to influence the utilization of new technology also arose from his organization's capacity to determine relationships between rapacious businessmen trying to have their weapons procured, and the allocation of Government monies towards procurements.(52)

Meigs extended his influence by vehemently opposing lengthy campaigns. Generals such as McClellan, Burnside, Hooker, and Meade who through indecision, reluctance to attack, or other weaknesses, kept armies in the field too long all suffered Meigs' wrath.(53) In particular Meigs was concerned that it cost \$600,000 per day to supply McClellan, rather than the results that McClellan was achieving.(54)

49. E. Risch, Quartermaster Support of the Army: A History of the Corps 1775-1939 (Washington DC, Office of the Quartermaster General, 1962:389); & Hattaway & Jones, "The War Board" (1982:2-3)

50. F.V.A. De Chanal, The American Army in the War of Secession (Kansas, Spooner, 1894:153)

51. Hattaway & Jones, "The War Board" (1982:2)

52. S.E. East, "Montgomery C. Meigs & The Quartermaster Department", Military Affairs (Vol.25[4], Winter 1961-62:186)

53. M.C. Meigs (General), "On the Conduct of the Civil War", American Historical Review (Vol.26[2], January 1921:295)

54. IBID:295

As an organization the USQMC failed to encourage newer organizations that were set up to manage novel technological entities. With balloons, breech-loaders, the telegraph, and repeating rifles, all causing inter-service conflict, the USQMC saw innovations as disruptive.⁽⁵⁵⁾ Meigs used his authority and position of power to ensure that the introduction of these innovations did not undermine the USQMC's operations. The administration of new technologies – rail, the telegraph, and balloon technology – were all to suffer under the administrative yoke imposed by the powerful USQMC Corps.

New agencies set up to promote the more effective use of new technology were all too often seen by traditional administrative bodies as a challenge to their authority. For example, the administrative functions performed in the quartermaster operational area were challenged by the advent of new organizations such as the United States Military Railroad Department (USMRD).

Establishment of the USMRD as a part of the War Department dated from 11 February 1862,⁽⁵⁶⁾ resulted from the wartime need to control railroad resources. The idea was to organise rail as a military tool to assist field operations. Under the executive control of D C McCallum, the Department would secure "a high degree of co-operation between the government and the railroad" enterprises.⁽⁵⁷⁾ As well, it would be responsible for the "restoration, operation or distribution" of rail resources.⁽⁵⁸⁾

The lack of lines and the necessity to restrict the use of rolling-stock and rail usage caused fierce debates between military leaders in the field and those civilians appointed to control the running of rail operations.⁽⁵⁹⁾ Attempts had been made by the political executive in 10 November 1862 to increase the autonomy of the rail Department's operations by issuing a Presidential Order. E D Townsend, the Assistant Adjutant General, issued on behalf of the Secretary of the War Department, Edward Stanton, a general order seeking to prevent field commands from hindering USMRD official

55. East, "Montgomery C. Meigs" (1961-62:192)

56. G.E. Turner, Victory Rode the Rails: The Strategic Place of the Railroads in the Civil War (Indianapolis, Bobbs-Merrill, 1953 reprint 1972:246)

57. Turner, Victory Rode the Rails (1972:247)

58. E.A. Pratt, The Rise of Rail-Power: In War & Conquest, 1833-1914 (London, King & Son, 1915:x)

59. G.F.R. Henderson, Stonewall Jackson & The American Civil War (Vol.I & II) (London, Longmans & Green, Second Edition 1902:108 & 121)

duties. It ordered:

...commanding officers of troops along the United States railroad will give all facilities to the officers of the roads, and the quartermasters, for unloading cars so as to prevent any delays ...commanding officers will be charged with guarding track... No officers, whatever may be his rank, will interfere with the running of cars as directed by the superintendent of the road.(60)

To further facilitate the USMRD's difficult role, McCallum divided it into geographic divisions, and in 1863 the Department was consolidated into two parts, a Transport Corps and a Construction Corps.(61) This separation was not only a reflection of the importance of the USMRD's functions; it also enabled some 10,000 men on the eastern and western theatres of war to concentrate on management of rail rolling-stock use and the maintenance or repair of railroad lines respectively.(62)

Major problems began to plague these bodies from 1863. Through the war there continued to be opposition between the civilian workers who formed the body of the USMRD and the regular army units. Although the leaders of the department were the only ones with the technical expertise to run railroads and construct railway lines, the authority of their honorary officers' rank was barely recognized by army officers. This situation further impaired the problems of co-ordination between the users of rail (soldiers) and the organisers of its proper functions (technicians). The conflict between Hermann Haupt, the leader of the Construction Corps (and officially a Major in the US Army), and General Pope in 1863 over the construction of lines and effective use of rail resources typified the problems of using new technology in military operations.(63)

Despite the Presidential directives confirmation of the USMRD functions, Haupt, first with General Sturgis and later with Pope, could not overcome intransigent traditional military opinions. Through frustration Haupt was driven to resign on 14 September 1863.(64) The Construction Corps' authority was continually being undermined by

60. United States-Military Railroads Department, U.S. Military Railroads: Report of Brevet Brigadier General D.C. McCallum Director & General Manager From 1861-1866 (Washington, 1866:41)

61. Pratt, The Rise of Rail-Power (1915:20); & Report of Brigadier General D.C. McCallum (1866:17)

62. Report of Brigadier General McCallum (1866:7)

63. Pratt, The Rise of Rail-Power (1915:43); & G. B. Abdill, Civil War Railroads (New York, Bonanza Books, 1961:20)

64. Pratt, The Rise of Rail-Power (1915:43 & 49); & Abdill, Civil War Railroads (1961:20)

regional military commanders. On 19 January 1864 McCallum felt compelled to report that:

... the railroad organisation of this department as decidedly defective, and, as far as I have been able to discover, there is a lack of will directed energy and seeming want of ability to comprehend the magnitude of the undertaking.(65)

Such comments reflect a number of problems confronting the USMRD. One of the most serious problems was that of administrative overlap. There was a serious lack of co-ordination between the Transport Corps role as controller of rail lines, the USQMD's role as controller of the rolling-stock, the Construction Corps' role as railroad repairer under the direction of the USQMD, and the army as a user of the lines. There also existed opposing opinions as to whether the rail lines should have purely logistical functions, or function as troop movers as well.(66)

From 1863 the progress in the use of rail in warfare was, however, still continuing. D C McCallum believed the use of rail as a military tool developed from an experiment with severe difficulties in 1861-62, to its peak as a successful reality in 1864 when it succeeded in supplying Sherman's army of 100,000 men and 60,000 animals with only a 360-mile single track and limited rolling stock.(67)

Confusion over its initial administration and control was to limit military exploitation of railroads through 1861 to 1863. There continued to be amazing efforts by the Construction Corps to devise new techniques to keep open or lay new lines; innovations in the use of rail for wounded; and moves to assist with tactical reinforcements. Yet the administrative confusion detracted from these innovative efforts. As the co-ordinated administration of the USMRD and the Construction Corps as part of the wider US Army organization improved, there occurred greater exploitation of rail as a military supply vehicle from 1863.

One of the advantages of having rail technology administered by a new military department was the inclusion of personnel with specific technical knowledge. This invariably made organizations set up to administer new technology more ready to instigate innovations that would enhance their own functions.

New technology, despite having a body created to specifically encourage its known advantages, was evidently restricted by the wartime institutional environment. This can

65. Report of Brigadier General D.C. McCallum (1866:14)

66. Wolseley, "An English View of the Civil War", North American Review (Part I) (Vol.148[390], January, 1889:559)

67. Report of Brigadier General McCallum (1866:43)

be confirmed by an analysis of the wartime management of the United States Signal Corps (USSC).

Despite the speed with which the telegraph became a tool of the military in the Civil War, its full potential was never realised. So although the military progressed through a number of organisational changes, they never facilitated proper use of the telegraph as a medium for military communication.

The USSC was formed as part of the Adjutant General's Department in October 1861. It was not until official reorganisation in March 1863 that the Corps received a semi-autonomous role in the military establishment. Even so, from October to November 1863 the USSC was loosely consolidated into an organised Signal Corps and a Military Telegraph Corps.(68)

By 3 March 1863 the two bodies had evolved with the Signal Corps having some 300 officers and 2,500 men under the command of Major A J Myer.(69) Myer's command dealt solely with visual field communications (flag, rocket flares, torches, and mirrors) and mobile field (tactical) telegraph systems. The Military Telegraph Corps under (Colonel) Anson Stager and (Major) Thomas J Eckert, with some 1,000–1,500 operators,(70) was attached to the USQMC and dealt with (strategic) electric telegraph material: the Beardslee and fixed lines. A third organisation can be nominally included. This was the Secret Service which handled the collection and transmission of cyphers and covert information.

Although military operators were given priority on all electric telegraph lines from 26 February 1862, the effectiveness with which these lines were used never attained their potential. The splitting of the USSC into two separate bodies did not remove the problems inherent in the administration of communications technology. Two major problems plagued the effective use of the electric telegraph. In the first place, there existed rivalry about which organisation should control telegraph resources. Myer wanted to control all telegraph operations on the battlefield and bring the communication system under the "compulsion and control" of the field commanders.(71) The other problem was between the civilian operators and their officers. This was the division between those who possessed the technical expertise to use the new technology, and opposition from the established military hierarchy which

68. Scheips in W.R. Plum, The Military Telegraph: During the Civil War in the United States (Vol.I & II) (New York, Arno Press, 1974;Introduction)

69. IBID:Introduction; & Coggins, Arms & Equipment (1962:106)

70. Nevins, "1861: A Primitive Administration" (1969:145); & Scheips in Plum, The Military Telegraph (1974:Introduction)

71. G.R. Thompson, "Civil War Signals", Military Affairs (Vol.28[4], Winter 1954:194)

found voice through the USQMC's desire to maintain control over the operation of fixed telegraph lines.

The 1863 splitting of the USSC to create a specific telegraph body not only served to accentuate the problems of co-ordination but effectively split the administration over signal operation.(72) By including the Signal Corps in the military hierarchy, it became subject to the politics of the system. As the personnel were still mostly of civilian origin (either enlisted or paid to work for the army) and the commanding officers lacked recognized status in the administration, the unit quickly got lost in the convulsions of Union military administrative problems. By November 1863 the Secretary of War E. Stanton decided to replace Myer because of his resistance to the reorganization.

The Telegraph Corps, on the other hand, was immediately isolated by the predatory USQMC which had already established its jurisdiction over fixed telegraph lines. Ultimate strategic control over telegraph operations fell into the hands of an older-style military body, that had its functions predetermined by officers with wider concerns. As the USQMC offered greater protection from antagonists, some benefits were derived from these arrangements. Even greater benefits could have been gained had the USQMC a desire to permit the USMTC to operate autonomously. However, it maintained the Corps' operations with a minimum of encouragement and left its civilian operators to function without complete military support. They permitted this out of the benevolent belief that the USMTC served some useful purpose, while believing it had no long-term future that would last beyond the end of the war.(73)

Despite the fact that the efficiency of telegraph communications was totally reliant upon the core of trained personnel provided by railroad companies, civilian personnel and their civilian commanders held only temporary officer status. This effectively made them subordinate to all senior army officers and their delegates.

The civilian operators were responsible for the improved technical efficiency of the telegraph system, and they enabled the potential of the field telegraph system and its technical development to be expanded. Nevertheless, the position of civilian operators was very unsatisfactory. As Plum recorded:

More complaint has been uttered by telegraphers on account of their anomalous position in the service, and its consequent evils, than all other causes united.(74)

72. IBID:198

73. De Chanal, The American Army in the War of Secession (1894:44)

74. Plum, The Military Telegraph (Vol. II) (1974:109)

The operators were subject to the burdens imposed by increased reliance on the telegraph system and were often blamed for inadequacies in the communication links. Often undertrained and without extensive telegraph experience themselves, they were involved in an organisation that offered them inconsistent wages that often fell below a foot-soldiers' wage.⁽⁷⁵⁾ Since it was never established exactly what status the operators and their civilian supervisors held in the military hierarchy, the relationship with military personnel was also uncertain.

The continued support for the Signal Corps and Military Telegraph Corps at Union Army Head Quarters command level was absent. Despite support from President Lincoln, Generals McClellan, Sherman, and Meigs, and Admirals Farragut and Porter, the telegraph never attained an autonomous role in the military hierarchy.⁽⁷⁶⁾ Paradoxically, while this uncertain status of telegraphic operations occurred, the Union Secretary of War Edward Stanton still believed:

The military telegraph under the general direction of Colonel Stager and Major Eckert, has been of inestimable value to the service, and no Corps has surpassed it.[sic]⁽⁷⁷⁾

Technical advances often only served to compound problems associated with using the telegraph. Advances in the power of electric batteries, which increased the range of field telegraph systems, confused the arbitrary boundaries between the administration of fixed lines, telegraph stations, and mobile field telegraph operations. The organization and operation of mobile field systems, which were intended to support front-line commanders, was left to a USSC that was devoid of any capacity to administer the use of fixed lines, or the use of Beardslee rail-mobile telegraph stations.

To more completely exploit the field telegraph's technical improvements, the technology needed one agency to autonomously manage its full range of functions. With the existing administrative overlap, and the absence of clear guide-lines on military deployment, there existed few commanding officers who were not only empowered to manage the new technology, but also able to use it to enhance their battlefield tactics.⁽⁷⁸⁾ This case may be further confirmed by the Northern deployment of balloon technology.

The Balloon Corps was established to administer a technology that, due to its novelty, did not easily fit into any existing military organization's jurisdiction. As innovations further refined operations, and added new functions, the problem of who was to

75. IBID:109

76. IBID:62-63 (Vol.I)

77. IBID:355 (Vol.II)

78. Coggins, Arms & Equipment (1962:63)

administer aeronautic technology became even more uncertain. As with the USSC and USMTC, the Balloon Corps' organisational weaknesses were to severely restrict the introduction of technology into military use. These weaknesses ultimately led to the Balloon Corps demise after the administrative reforms of 1863.

The potential of the balloon was only gradually realised by military commanders. From the very early days of the war, the aviators had to lobby the US Army to get balloons deployed. Balloons were then able to gradually put to use for conducting aerial observation, field communication, and artillery observation.⁽⁷⁹⁾ Yet the US Army had no consensus on how balloons could complement battlefield tactics.

As with the telegraph and railroad, civilian operators had to be employed to deploy the balloon technology. As with other corps, it quickly became apparent to T S C Lowe, the leading civilian officer in the operation of balloons, that military officers had "...no knowledge whatsoever of aeronautics and were often a serious hindrance rather than a help."⁽⁸⁰⁾ This encouraged greater reliance on civilians to provide the necessary technical skills and support personnel. As balloons became more widely used, technical changes were introduced to refine their operation. This served to further increase the complexity of equipment, and, ironically, raise the level of skills necessary to properly deploy balloons.

The US Balloon Corps in 1862 has been described as a "loosely organised, poorly administered, and decentralised mixture of civilians and military personnel..."⁽⁸¹⁾ The organisation's internal cohesion was further destroyed by bureaucratic red tape and army regulations that governed everything from equipment supplies to personnel policies. Compounding these problems, the Corps went from the control of the Bureau of Topographical Engineers, the USQMC, the Corps of Engineers, and finally came under the Signal Corps from March 1863 until April 1863, when it was disbanded.⁽⁸²⁾

The confused attempts to bring the Balloon Corps into central control severely restricted aeronautical operations on the battlefield. Whilst the balloon was used throughout the war, poor organisation, unco-ordinated efforts and lack of liaison with separate regiments hindered its usefulness. It was too novel a technology to fit easily into the existing military organizations that toyed with administering its functions.

79. F.S. Haydon, Aeronautics in the Union & Confederate Armies (Vol.I) (Baltimore, A Doctoral Dissertation, 1941:93); Coggins, Arms & Equipment (1962:6-7); & De Chanal, The American Army in the War of Secession (1894:45)

80. Quote in Haydon, Aeronautics in the Union & Confederate Armies (Vol.I) (1941:303)

81. IBID:280

82. IBID

These organizational deficiencies in the hierarchical army structure served to severely retard further extension of technical innovations on the core technology. Refinements made by innovators improved the military utility of the balloon. Whilst serving to highlight the unlimited potential of the core technology, aerial operations never reached their full capacity.

It is only in the Corps of Engineers organization that the established technical expertise was committed towards improving military operations by increasing the use of significant innovations. As with the USAMC, the operations of the Corps of Engineers were responsible for promoting more efficient usage of available technology. Established prior to the war and considered an integral part of the military hierarchy, the engineer organisation's greatest benefit was its ability to promote the conditions where innovations could enhance military operations.

The expansion of military engineering during the Civil War represented not only increased use of practical knowledge but the collation and use of civilian know-how for military use.⁽⁸³⁾ The importance of existing under-developed pre-war technical knowledge can not be underestimated. Perhaps the best example of this is Denis Hart Mahan's pre-war writings that were to influence the wartime efforts of the Engineering Corps of both sides. The relevance of trench warfare – battlefield fortifications – was not immediately apparent at the beginning of the war. These skills had to be rediscovered and then enhanced as the war progressed.⁽⁸⁴⁾

As with the advances in medical treatment, it is difficult to pin-point where the Union Corps of Engineers directly promoted technology. The Corps had two main responsibilities. It had to improve the performance of transport technology through the provision of better rail lines, and the construction of better supply and command centres. The Corps was also heavily involved in improving defensive tactics through the construction of defensive positions.

With the extension of transport links and the utilization of civilian rail engineers, the Corps of Engineers became essential in the struggle to satisfy demands placed on the logistics system. Engineers contributed to the improvements in rail lines, canal systems, and road links. They also built supply centres, administered the hardware for construction efforts, and rivalled the USQMC's own capacity to distribute these construction materials.⁽⁸⁵⁾ These efforts also complemented the efforts of specialised

83. J.K. Finch, "Engineering & Science", *Technology & Culture*, (Vol.2[4], Fall 1961:327)

84. Hagerman, *The American Civil War* (1988:ch.5); & the Corps of Engineers instructor at West Point, D.H. Mahan's, *A Summary of the Course of Permanent Fortification & the Attack & Defence of Permanent Works* (Richmond, West & Johnston, 1863)

85. De Chanal, *The American Army in the War of Secession* (1894:190–191); & Report of Brigadier General McCallum (1866:18)

engineers working for the USMRD in the Construction Corps. Together they reconstructed ruined rail lines and rebuilt sabotaged bridges (with significant innovations such as pre-constructed trusses and inter-locking wooden beams) to quickly re-establish support facilities.(86)

Army engineers were well commanded by General Joseph G Totten until 1864 and then by General Richard Delafield. Regardless of the wide area over which the war was carried out, and the particularly wooded and rugged terrain of the eastern campaign, the Corps' leaders managed to maintain a semblance of co-ordinated effort. The more their operations complemented existing Corps functions, the better the Engineers were able to meet demands placed upon them. This enabled the Corps to survive the 1863 administrative reform relatively intact. As such, they were administratively prepared to accept the burdens placed upon them when the pitched battles of the last three years of the war were undertaken.

The history of the Corps to 1863 reflects only a marginal role in technology change. However, one of the greatest contributions to promoting innovations in the Civil War was the Engineer Corps' construction of defensive networks.

Not only did these improvements consolidate past techniques and ideas: they introduced new defensive methods. This was to alter the concept of defence and attack. Improved engineering also encouraged the defensive deployment of weapons that could increase fire-power. The defensive deployment of explosive devices such as land torpedoes (mines) and hand-grenades was also encouraged. In effect, the defensive strength of soldiers was to be promoted over that of the attacking force.(87)

It was in the combination of a number of novel technical innovations and improved techniques that mark the Civil War as a period of great significance in the quest for the origins of trench warfare tactics.(88)

Engineers used defensive network improvements such as well-dug trenches (at least seven feet deep); forward redoubts connected by trenches to the main network; sand-bagged walls and casements; firing steps for riflemen to engage the enemy over casements; bomb-proofed command and storage areas; chevaux-de-frise (3-metre logs, 18-centimetres thick, with 90-centimetre sharpened spikes set at right angles projecting from the log) sharpened stakes;(89) wire entanglements; and torpedoes

86. Report of Brigadier General McCallum (1866:7, 11 & 25); Abdill, Civil War Railroads (1961:30-40); & Turner, Victory Rode the Rails (1972:48-50)

87. R.A. Leonard, A Short Guide to Clausewitz On War (London Weidenfeld & Nicolson, 1967:30)

88. Hagerman, The American Civil War (1988:253)

89. Coggins, Arms & Equipment (1962:102)

attached to trip-wires in wire entanglements, or torpedoes with pressure-sensitive fuses laid in front of trenches (See Appendix 11) to stop massed infantry or cavalry assaults.(90)

As the war progressed heavy howitzers, accurate rifled artillery with percussion fuses, small trench howitzers, and surprise attacks were employed to break trench networks. The sappers of the Corps of Engineers responded with redoubts for pickets and zig-zag trenches to reduce shrapnel vulnerability, and also reshaped trench networks that supported each other with cross- and flanking-fire.

Both the North and the South became extremely proficient at constructing these trench networks. One informed observer, the Comte de Paris, believed that the expertise of the Southern engineers in particular delayed the South's defeat for at least a year.(91) Another observer, the Duke of Cambridge, was so impressed by the innovations in defensive engineering techniques that he declared the spade to be "a great element in campaigns" and a "new element in the features of the war." (92)

The Corps was responsible for converting existing knowledge into improving practices. Railroads, other transport systems, defensive networks, and miscellaneous endeavours all benefited by having their supporting role to contemporary armies enhanced. Under this guidance new technology was more capable of achieving its potential. It was not the Corps' conscious role to directly promote new technology, but as a mature, established organization it established an operational climate that was conducive for the introduction of military innovations.

6.3 The Impact of Northern Executive Leadership on the Administration of Military Technical Change

Enterprising innovators had only two chances to promote their products or ideas: when government contracts were issued or when selective field tests could be secured.(93) Due to the indiscriminate nature of contract issuing and product testing, many entrepreneurs were not able to promote their product.

The main means by which an entrepreneur to gain acceptance for his or her innovation was to secure and maintain the endorsement of a prominent member of the political executive.

90. J.F.C. Fuller, *The Decisive Battles of the Western Worlds* (Vol.III) "From the American Civil War to the End of the Second World War" (London, Eyre & Spottiswoode, 1956:88); & Luvaas, *The Military Legacy of the Civil War* (1959:4 & 33)

91. Luvaas, *The Military Legacy of the Civil War* (1959:84)

92. Quote in IBID:107

93. Shannon, *Organization & Administration* (1965:115)

The role President Lincoln played in the promotion of Northern military innovation stands testimony to the importance of senior officials. He was responsible for lifting select innovations out of the confused system of assessment and encouraging their promotion. Lincoln promoted the balloon, rapid-fire guns, and expressed a continued willingness to review promising innovations that could not obtain official endorsement. That he felt the need to exert such an important influence on the adoption of new technology, is a reflection of his lack of confidence in the military bureaucrats.(94)

Lincoln's influence on the adoption of new technology is not questioned, but was it a positive influence that overcame bureaucratic problems?(95) Or was it more an example of political interference that handicapped the pursuit of military efforts?(96)

In many cases a feature of the Northern wartime procurement process was the willingness of military bureaucrats to yield authority to the politicians. As the framework of military bureaucracy was still stretching to accommodate the new demands placed upon it, the imposition of orders (particularly from the Executive offices of the President) removed the burden of responsibility from military men. This confirmed the authority of politicians to interfere in the process of military procurement.

When the military (in General Order Number 54 of 1861), acknowledged the Act For the Better Organization of the Army, they confirmed the President's Executive direction over the Army.(97) It was President Lincoln who became vested with the ultimate responsibility for encouraging the more efficient organization of the Union Army.

The absence of an effective Staff Command system inhibited President Lincoln's ability to delegate responsibility for military procurement.(98) Whilst General Hitchcock was attempting to enforce strategic control over military operations, President Lincoln still maintained active oversight of these operations. The General Staff understandably had little ability to restrict military decision-making to their own ranks. The War Board or Committee, which sat in a formal policy role in the General Staff, lasted only from 1861 until July 1862. From then until war's end its power resided in its informal capacity to exert central control on established projects.(99)

94. see Bruce, Lincoln & the Tools of War (1973:ix)

95. IBID:81

96. L.H. Johnson, "Civil War Military History: A Few Revisions in Need of Revising", Military History (Vol.17, 1971:129-130)

97. Official Records, (Series 3, Vol.1) (1899:395-403)

98. Hagerman, The American Civil War (1988:40)

99. Hattaway & Jones, "The War Board" (1982:3)

Lincoln's involvement in military procurement reflects a critical failure to develop an adequate framework for evaluating new designs. There exist numerous examples of ranking political and bureaucratic members using their power to sponsor weapons that were poorly designed, were totally inappropriate to battlefield needs, or tied up manufacturing and financial resources beyond any military justification.(100) Lincoln's role in the procurement process may be interpreted in a negative way because his actions seem to promote outside interference in the Ordnance Bureau's operations. The Army and Navy Ordnance Bureaus were subject to decisions, made independently of their jurisdiction, that sought to promote an isolated innovation. In the confused environment of 1861, military officials utilized this intervention by political figures to further abdicate their own responsibility for the procurement process.

The good intentions of the President could not be doubted, for he firmly believed that if he did not encourage the development and use of better weapons, no-one would.(101) The increase of political interference further opened the procurement process to another obstruction; popular discussion. As Lord Wolseley wrote in 1888:

The discussions from Washington and the criticisms from Washington, based upon the loose and rampant public opinion of the day, were in every instance wrong, and were disastrous to the cause of the Union.(102)

The prevalence of these public-inspired criticisms made it extremely difficult for any organisation to plan without perceived political priorities being imposed. Lincoln acted as a filter for the expression of political patronage, rather than as an advocate for the use of political power by politicians to influence procurement policy. Often it was only the support of the President that allowed certain technologies to be introduced.(103) The introduction of ironclads, breech-loaders, balloons, and some novel weapons relied on technical innovations that were influenced through priorities imposed by the President.

Popular public and political opinion greatly influenced the adoption and deployment of the Monitor.(104) At first societal opinions were unsupportive of innovative effort. The popular belief upheld that the Monitor, far from being a great advancement, was

100. Competition between Federal, State and private officials over the purchase of arms promoted competition and wide corruption. This was especially so with overseas contracts; see Shannon, Organisation & Administration (1965:116-117)

101. Bruce, Lincoln & the Tools of War (1973:81-82)

102. Wolseley (Viscount), "An English View of the Civil War", North American Review (Part IV) (Vol.149[394], September 1889:292)

103. Johnson, "Civil War Military History" (1971:128)

104. E.J. Hess, "Northern Response to the Ironclad", Civil War History (Vol.31[2], June 1985:126-127)

"Ericsson's Folly".(105) After its success at Hampton Roads the Monitor design received adulation and support. This support flowed into the development of other ironclad designs.(106)

Military representation for the Spencer repeating rifle were similarly biased against its introduction. The 1856 Springfield Muzzle Loading Rifle was popularly held up by senior military bureaucrats as the most effective of American weapon designs. Not until soldiers and State governments began to adopt BLR arms, outside established Federal procurement procedures, did support for the exclusive endorsement of the Springfield begin to wane. As the public perceived the value of new designs – such as the Monitor – administrators' development of replacement technologies often similarly followed public opinion.

Lincoln's most dramatic action came when he directly intervened in August 1863, to assist with the adoption of Christopher Spencer's repeating rifle. By replacing General James Ripley as the Chief of the Northern Ordnance Bureau, Lincoln removed a major antagonist of BLR technology and opened the way for a more considered review of new technology. As the President's faith in his administrators increased his persistent use of executive powers to directly manipulate the procurement process decreased.

The problem of getting senior military officers to give direction on the technology to be tested led President Lincoln to enforce his role as *de facto* Chief of Staff and Commander-in-Chief. He felt the Generals' reluctance to innovate reflected a wider failure to maintain focus and control in the war.(107)

6.4 Contrast Between Northern Industrialization and Southern Improvisation

Since the beginning of the war the Union grand strategy of blockading the South had isolated the Confederate forces from their external arms supplies. Compounded by the lack of financial resources to buy foreign arms, the absence of supplies served to place greater emphasis on internal technological developments.

105. C.W. MacCord, "Ericsson & His Monitor", North American Review (Vol.149[395], December, 1889:462)

106. This was despite the differences in designs. Hess, "Northern Response to the Ironclad" (1985:131); & D.C. Allard, "Naval Technology During the American Civil War", The American Neptune (Vol.49, Spring 1989:116)

107. H. Hattaway & A. Jones, "The War Board, the Basis of the United States First General Staff", Military Affairs (Vol.46[1], February 1982:2 & 4)

Throughout the Civil War the North maintained a naval superiority that could not be offset by any number of Southern innovations such as torpedoes, torpedo boats, fast patrol boats, submarines, and ironclad rams.(108)

Conversion of the Merrimac, and continuing efforts by the South to copy a winning weapon, created a profound fear in the North that the South could perhaps produce an effective weapon.(109) While not overcoming the North's confidence in its own arms superiority, this fear became the spur for Northern organizations undertaking innovation to match Southern ingenuity and to outstrip its enemy's capacity to produce ironclad vessels.(110) The Northern Naval Department's actively encouraged research and development on steam engines, large calibre rifled muzzle-loader cannon, better armour-plate construction, turrets, propeller-drive systems, and overall incorporation of these features into a naval weapons system.(111)

Through improvisation and innovative designs the Confederacy was able to fill the shortfall in combat equipment. Early in the war at least, the difficulty caused by the blockade was offset by the South's resourcefulness. This in a small way compensated for the resource superiority held by the North.(112) The Confederacy also benefited from having private innovators who were able to merge their efforts with military needs. This was unlike the early wartime situation in the North, where much of the innovative effort seemed to be knee-jerk reactions to perceived military demands.

The immediate threat posed by the North also served to galvanize the Southern administrators. Where available resources existed in the South, concentration was more likely to be focussed on a few technological developments. This was enhanced by the Confederate people being inspired by the success of innovations such as the ironclad CSS Virginia, torpedoes, and the individuals who, by their endeavours, made these technologies possible.

The Confederacy did not escape the proliferation of military bureaucracies.(113) However, the bureaucracy was severely restricted in its operations by the essential lack of industrial and financial resources. The endeavours of a few individuals came to shape the focus of technological development in the Confederacy.

108. V.C. Jones, The Civil War At Sea (Vol.III) "July 1863–November 1865 – The Final Effort" (New York, Holt, Rinehart & Winston, 1962:60)

109. N. Reingold, "Science in the Civil War: The Permanent Commission of the Navy Department", Isis (Vol.49[3], No.157, September 1958:307)

110. G. Elliot, "Her Construction & Service" (Part I) of "The Career of the Confederate Ram Albemarle", The Century Magazine (Vol.36[3], July 1888:420–422)

111. Hunter-Dupree, Science in the Federal Government (1957:127)

112. J. Coggins, Arms & Equipment (Garden City: New York, Double Day, 1962:126)

113. R.D. Goff, Confederate Supply (Durham, Duke University Press, 1969:129)

Theodore Stoney was one of the Confederacy's skilled innovators. At his own expense he designed, built, and combat tested the David (MTB), and then present the craft to the CS Navy.(114) This illustrates not only the 'know-how' of innovators, but the important role such motivated individuals could play in the war. The deployment of the David also served as an example to contemporary innovators that a low level of organizational capacity need not hinder the deployment of technologies.

The Confederate shipbuilding programme was by no means unco-ordinated or compromised in size to fit available industrial resources. Some 150 ships were laid down during the war with only 50 being completed. However, resources were concentrated on producing some 22 ironclad vessels.(115) As the war continued, the lack of resources and the strategic requirements for defensive shallow draught vessels precipitated the construction of 'improvised' ironclad.

The shortcomings of the South's continued lack of manufacturing strength became all too evident by 1863. Whilst the David may have been deployed with relative ease, its further success was restricted by the lack of resources necessary to develop and manufacture more of these vessels.(116) The strength of commitment from senior administrators could not secure scarce resources. No amount of support from the Naval Secretary Stephen Mallory or President Jefferson Davis, could promote torpedo technology while there existed a fundamental inadequacy of available resources.(117)

The fact that the ironclad, torpedo, MTB, and the submarine were inspired by a desire to give Southern forces the basic tools with which to defend the Confederacy, developmental issues were focussed. With little or no capacity to prevent the US Naval supremacy, by 1864 it became clear that it was on land that the South needed to commit resources to prevent immediate defeat. From 1863 the war of attrition soaked up CS Army resources faster than they could be replaced. The innovative efforts suffered two main problems. Firstly, available resources and administrative support had to be directed towards maintaining the existing military effort, while the innovative effort became concentrated on simple technology that could fill the void left by the decreasing capacity to wage war.

With the advent of the war of attrition from 1864 to 1865, the real problems with the South's lack of industrial resources became evident. They could neither produce a weapon to slow the advance of the North, nor replace rail roads, bridges and basic

114. R. McBride, Civil War Ironclads (New York, Chilton Books, 1962:109)

115. Allard, "Naval Technology" (1989:118); & W.N. Still, Iron Afloat: The Story of Confederate Ironclads (USA, Vanderbilt University Press, 1971:227)

116. Coggins, Arms & Equipment (1962:149)

117. M.F. Perry, Infernal Machines (Baton Rouge, Louisiana State University Press, 1985:16)

weapons needed to prolong the war. This situation is reflected as early as April 1863 in the comments by the Confederate Secretary of War J A Seddon. He estimated that at least 49,500 tons of rail were needed annually, but the estimated combined production from the largest rolling mills in Atlanta and Tredegar, could only produce 20,000 tons.(118) He also admitted that to achieve this production figure substantial diversion of manufacturing resources from current arms production would have been required.

For the South the fundamental lack of resources could never be overcome by improvisation or the creation of ingenious technologies that could better perform specific military functions. While the North lacked the organizational capacity early in the Civil War, it still possessed substantial industrial and production resources. These fundamental differences between the USOB's ability to administer technology after 1863, and the capacity of its Southern rival, illustrate some important factors affecting Civil War administration of technical change. From being a barrier to technology change in 1864, the USOB grew to become instrumental in promoting technological change. The reverse trend is evident in the South: as the war progressed the Confederate Bureau of Ordnance became increasingly less able to promote new technology.

The capacity of the ordnance bureaus to provide new technologies seems to be paralleled by their ability to firstly satisfy existing production demands. Excess administrative and physical resources had to exist before innovative activity could be properly sponsored. In satisfying their Army's arms demands up until 1863, the Confederacy was able to use improvisation and available resources to match the mass productive capacity of the North.

The contrast in arms development between the warring sides in the Civil War is best reflected by the fact that by 1864 the North had moved away from the conditions of 1861 in which MLR small arms were first choice acquisitions. In the Confederacy by the end of the war the MLR still dominated the arms replacement programme. Whilst having the advantage of narrowing its range of shoulder fired arms and calibres used, the South was utilizing these weapons by default.

Weapons technology became increasingly more technically sophisticated and as the war progressed it seems demands increased both on the administration of the weapons procurement process, and on production resources. Neither the Northern or the Southern ordnance bureaus were able to maintain staffing levels that could both handle all the wartime demands placed on them, and still assess new technologies.

118. Official Records (Series 4, Vol.2)(1900:512)

Up to 1862, the USOB had only 59 officers to handle arms contracts, inspection of plants and arms, repairs, service and field liaison, and assessment of all new technology.(119) Major Thomas Rodman, inventor and member of the USOB, was aware that a dilemma existed because "every officer had so much to do that he could not spend much time on inventions." (121)

Towards the end of 1863, General Gorgas, the Southern Chief of the Confederate Bureau of Ordnance (CSBO), made a similar complaint when he noted that operations had altered to such an extent over twelve months that:

...the department has been chiefly engaged in the supply of the armies in the field. Very little time has been devoted to scientific research or experiments(121)

Throughout the war the CSBO struggled to maintain the army's on-going weapon needs. General Gorgas' greatest achievement was the removal of his organization from the dependence upon other Bureaus and civilian leaders. (122) By the end of 1864, any gains made in increased administrative efficiency had been eroded by the Ordnance Bureau having only some 300 men of all ranks serving in the Confederate forces.(123) At the same time the Bureau had an accumulated debt of \$5.6 million.(124) The situation had become so critical that General Gorgas lacked not only money to employ labour, but the resources to clothe and feed those men already working in the Bureau.(125)

By the end of 1864 the USOB had attained a much sturdier capacity to meet the demands placed on it. Organizational problems were reversed to such an extent that on 22 October 1864 the Northern Chief of the Ordnance Department, General Alexander Dyer, was able to report:

The increase in the manufacturing capacities of the arsenals and armories has already gone far toward supplying the large demand for arms and other ordnance stores, and, in conjunction with private manufacturers in this country, has rendered us independently of foreign supplies.(126)

119. Bruce, Lincoln & the Tools of War (1973:32)

120. IBID:70

121. Official Records (Series 4, Vol.2)(1900:955)

122. Goff, Confederate Supply (1969:158)

123. Official Records (Series 4, Vol.3)(1900:1106-1107)

124. IBID:975

125. IBID:1071

126. Official Records (Series 3, Vol.4)(1900:801)

Under the guidance of Generals Ramsey and Dyer the Northern Ordnance Bureau increased its capacity to meet weapons demands. This permitted the administrators to concentrate on the better management of other services.(127)

Access to official institutional support did go some way to help nurture certain technical developments. But the promotion of key innovations mostly occurred through the restricted efforts of institutions set up to specifically administer new technology. These included the Confederate States Submarine Battery Service, the Torpedo Bureau, Naval Department and Confederate Bureau of Ordnance.

Yet without manufacturing resources, the Southern institutions had little capacity to contribute to the wider development of successful military technologies. An example of this situation is where General Rains (CSA) designed and deployed ingenious land mines at Southern defensive positions. He admitted that given more time and resources, the quality of the torpedoes, and the defensive capabilities of the mine-fields, could have been vastly improved.(128)

The South may be credited with novel ideas that precipitated the evolution of important innovations. Nevertheless, the Confederacy lacked the technical and industrial resources to produce advancements that required extensive commitment of resources to experimentation and development. From 1864 it was apparent that only in the North were there the resources to support technical endeavour on innovations such as, telegraphic communications, improved ironclad armour, ammunition advancements, or the perfection of specific designs, like the lever-action repeating rifle.

It was the Northern military re-organization in 1863 that rekindled military technology change. As organisations had their chain of command delineated and control reasserted, they also became better able to adopt innovations that enhanced their operations.

As they became better able to control their wartime operations, these mature bodies became important agencies for identifying areas in need of technical change. The process of recognizing weapons innovations that held some potential, and developing and testing them further, was hastened. But from the time when the military administrations had to respond to the mass armies raised in 1861, the streamlining of the system never fully overcame the over-bureaucratization of the military administration, nor the lack of clear directives on military demand.

127. Especially see the report of US Ordnance Bureau Chief, General Ramsey to the Secretary of War on the reduction of costs and the appropriation of \$2 million in August 1864, IBID:586

128. F.A. Parker, *The Battle of Mobile Bay* (Boston, A. Williams, 1878:130-131)

Where organizations were established for the administration of new technology, innovative activity was more likely to be promoted. Where innovations were able to demonstrate that they could improve military operations, their adoption was likely to be more favourably considered. However, this did not ensure that the technology would be successfully adopted. The most successful innovations seem to have complemented existing military tools and been able to gain the endorsement of military organizations.

The deployment of new technology was influenced by the capacity of the responsible organizations to both acquire the necessary technical expertise, and avoid encroachment upon existing military organizations' jurisdiction. This marriage between technical expertise and military authority was difficult to achieve. It meant that all too often new organizations were unable to operate under the predatory gaze of traditional military Departments.

Overall, the introduction of innovations was best conducted when the person responsible for the nurturing of new technology understood its operation and was capable of promoting the innovations' use as a supplement to existing military activities.

CHAPTER 7: REASONS FOR THE STUNTING OF MILITARY INNOVATIONS

In the previous two chapters the general factors and specific environmental (administrative) barriers to full exploitation of a new Civil War technology were examined. This chapter is intended to synthesize the lessons from the previous chapters and focus on the technical reasons why an innovation, in the wartime environment, may fail to be fully utilized.

In this chapter it will often be the less notable or technically unrefined ideas or designs that stand as examples for greater technological development in the future. This is to be expected. As the focus of this chapter shifts away from the successful technologies that went into mass production, the designs advancement over previous technical knowledge becomes the most important measure.

At least five main reasons can be advanced to explain why technological designs failed to be satisfactorily introduced. The first, and most obvious, is the designs' fundamental lack of technical merit. The next reason is the problem that "fashionable innovations" deflected resources away from a technology with merit, to another with "popular" support. The lack of testing and development on innovations also provided a third major reason why there was a failure to consolidate technical advances.

Another of the most persistent problems confronting new military technology, was the inability of Civil War military organizations to recognize the technical (and tactical) significance of some designs. Finally, a lack of technical development often occurred because innovators were recasting existing technology and technical know-how. Designs rarely improved on the relatively static technical designs already in existence.

The lack of technical advancement in many designs left them devoid of any developmental merit. Such designs did not accomplish their end purpose any better than existing technology and, at best, served only as technical lessons for future innovators.

Regardless of their lack of technical merit, many poor designs were still adopted during the Civil War. This could be due to the entrepreneurial flair of the innovator, wartime confusion that failed to adequately test a proposed design, or patronage from a prominent official that enabled a government contract to be issued for a limited production run. These innovations were doomed to become short-sighted blights on the wartime military innovation process.

One Northern official, when reviewing experimental torpedo designs, believed that it was impossible for committees to select the most technically effective design as the:

War Department and the Chief Engineer...were worse than opportuned by the..inventors, everyone of whom demanded an examination of his plan or model.(1)

Entrepreneurial skills aside, a number of innovators possessed advanced technical ideas that failed to be amalgamated into a coherent design. When the design went into production it was still at the unrefined, experimental stage. Many Civil War innovations could fit this description. In a more specific context it applies to those innovations that did not enter into service because their production models were so far from complete that they would require a complete re-working to make them competent tools of war. Such designs would include the Gorgas smooth-bore, rapid-fire gun,(2) both the Northern and Southern submarine designs, and attempts to make a more accurate form of guided rocket.

Unfortunately for the evolution of military tools, many of the better innovations had to compete with very poor designs for official attention. Many poor designs never progressed to the point of testing or introduction but constantly served to divert attention away from better designs. Consequently, potentially sound designs did not make it through an overburdened system of assessment. To alleviate pressure on their deliberations, examination committees were more likely to consider innovations that were either presented to them in a more complete format, had a simple design concept, or had actually proved themselves in service.(3)

Not all weapons advancements were easily achieved by a re-assessment of existing technical knowledge. The construction and, therefore, development of the BLR cannon was severely limited by the strength of iron. The concept of breech-loading cannons was in advance of American industries capacity to produce wrought iron breech-loading mechanisms that could withstand the pressures produced on firing. It was not until the wrought iron was used in conjunction with an improved quality steel inner sleeve in the barrel, that progress in the manufacture of cannons could even begin to make headway. Although Northern industry made progress with the Rodman cannon, the overall advancement in the manufacture of all steel cannon or breech mechanisms were not to be successfully completed until after the war when the technical lessons from the successful German manufacturers Krupp, became available.(4)

1. M.F. Perry, *Infernal Machines* (Baton Rouge, Louisiana State University Press, 1985:28)

2. C.B. Colby, *Civil War Weapons: Small Arms & Artillery of the Blue & Grey* (New York, Coward-McCann, 1962:19)

3. Perry, *Infernal Machines* (1985:29)

4. R. Routledge (ed), *Discoveries & Inventions of the Nineteenth Century* (London, Bracken Books, 1989:137-138)

The capacity of existing technology in the arms factories to produce these new arms was equally significant. For instance, the fact that the North produced armour plating in 1.5 inch thickness was due less to demand, than the fact that iron plate over 4 inches thick, could not be cut by existing guillotines.(5) Also, if iron plate was more than 1.5 inches thick (such as on the Monitor design), it could not be trimmed with existing shears. It was not until the end of the war that production technology had advanced enough to handle 5 inch plates. This contrasts with England where rolled iron plates 12 inches thick were being made.(6)

Despite the seemingly limited wartime advance in the production of iron plate in the North, it still represented an important process of industrialization, whereby production capacity sought to satisfy known demand. In this case military requirements were no longer able to be met by individual entrepreneurs competing to satisfy unplanned government demands. As specifications became embodied in contracts, especially for armour and ordnance, military needs were being filled by firms with a proven ability to overcome technical limitations and produce the new technology.(7)

By way of contrast, rocket technology with its small base of truly significant pre-war technical advancements, seems to have gained little over the course of the Civil War. Used both on land and at sea, innovations seem to have only produced rudimentary improvements in guidance, explosive loads, engineering integrity and overall tactical application.(8) The lack of fundamental advancements in technical knowledge in no small way affected the efforts expended by innovators who were trying to improve the rocket as a combat weapon.

The South's efforts to produce a repeating firearm led them to utilize known technology in order to produce the Sibert Magazine Rifle Model of 1861. While a new design, it drew exclusively from technical knowledge that was outmoded prior to the war.(9) Intended more to fit the manufacturing capabilities of the Confederacy, this design never possessed either the technical basis or military utility to see it become the source for further development.

As prominent officials and the public became aware of a technology's battlefield performance the development of these designs became more fashionable. The effect of

5. V.S. Clark, "Manufacturing Development During the Civil War", in R. Andreano (ed), The Economic Impact of the Civil War (Cambridge, Schenkman, 1967:64)

6. IBID

7. M. Howard, "War & Technology" RUSI (Vol.132[4], December 1987:20)

8. P.D. Olejar, "Rockets in Early American Wars", Military Affairs (Vol.10, 1946:16)

9. C.E. Fuller & R.D. Steuart, Firearms of the Confederacy (Huntington, Standard, 1944:204)

such support was to restrict the introduction of better technology, or to curtail the introduction of other more advanced technology that lacked public endorsement.

The BLR is a good example of this type of situation. BLR technology was increasingly being adopted by both the military and the US Ordnance Bureau, but as one design was being officially promoted, another would lose endorsement. The resulting staggered and diffuse production of breech-loading small arms made it impossible to tool-up Northern industry for any production based around the best weapon types. The extra competition of the repeating rifle against the BLR meant that in the long run officials tended to support existing BLR technology only because of the cost of adopting repeating rifle technology.(10)

In the case of repeating weapons - Gatling gun, rifles and hand guns - the initial competition was dominated by the desire for production contracts. Thus design integrity and full development became secondary to the speed with which a design could be presented to prominent officials. Research and development on existing designs was more likely to be seen as an admission of fault, rather than an acceptable design refinement. A design without the support of a prominent official or political patron was unlikely to hold the attention of those responsible for weapons procurement.(11) A number of similar situations occurred with examples such as the rapid-fire weapon designs receiving less attention as the seemingly more reliable Gatling was developed.

Naval technology was also subject to public endorsement or condemnation.(12) The success of the Monitor and fear inspired by Confederate ironclads served to foster informed debate on the technological nature of this new form of naval warfare,(13) yet did not promote the balanced assessment of ironclad designs.(14)

The MLR cannon ammunition is another example of how a technology tended to divert attention away from a new area of design work; in this case the need to concentrate resources on developing a better breech-loading design. The superior penetration power of smaller calibre high velocity BLR cannon, over heavy calibre MLSB, was ignored as improved manufacturing techniques allowed several design improvements on the MLSB. Also of note was the technical improvements to the balloon as a

10. C.L. Davis, Arming the Union (Port Washington, Kennikat Press, 1973:145)

11. This was illustrated with the excellent Peabody BLR design's inability to win official endorsement in 1864 as resources were being committed to the adoption of the Sharps and Spencer designs.

12. E.J. Hess, "Northern Response to the Ironclad", Civil War History (Vol.31[2], June 1985:134)

13. D.C. Allard, "Naval Technology During the American Civil War" American Neptune (Vol.49, Spring 1989:114-115)

14. Hess, "Northern Response to the Ironclad" (1985:137)

stationary observation platform which limited the development of it as a free floating aerial weapon.

Lacking an overall picture technical innovation, both sides seem to have lapsed into supporting the latest, most popular military tool. An even more backward step was taken by both sides when new technology was introduced at the expense of existing, more viable technology.

The most obvious examples of such a situation is where the Union Repeating Gun (Coffee Mill Gun) yielded any significant design developments it had instituted to later rapid-fire weapons, in particular the Gatling gun. The switching of support between designs affected each innovation's technical development. Overall, the designs did not reach a perfected mechanism, nor permit those employing the weapons to devise appropriate tactical uses.(15)

A prevailing military belief held that the BLR performed a similar function to the rocket, but with much greater success. The development of rocket technology suffered as a consequence. As artillery men manned most of the rockets and machine-guns deployed on land, it was their enthusiasm for other new forms of technology, such as advanced rifled ordnance, that dominated from 1863.(16) As C Sleeman noted, the failure to introduce rifle calibre machine-guns could in part be also attributed to:

the powerful opposition of the artillery, due in a great measure to an unreasoning and exaggerated fear that these weapons, if introduced, would threaten the very existence of artillery.(17)

As the machine-guns were mounted on gun carriages and weighed about the same as a light field or mountain gun, the weapons were logically and logistically perceived by contemporaries to be the responsibility of artillery men.(18)

The development of the BLR ordnance is another example of an advanced innovation that had its promotion stunted by new designs. The failure to refine Northern BLR ordnance designs, particular the heavy wear and occasional failure of such innovations as the Parrott BLR,(19) diverted innovators towards what they considered to be the more rewarding possibilities of improving the performance of MLR ordnance. This led

15. See General Ramsey (Chief of USOB) to E. Stanton on the outdated nature of rocket technology; Official Records, War of the Rebellion, A Compilation of the Official Records of the Union & Confederate Armies (Series 3, Vol.4) (Washington D.C., Government Printing Office, 1900:497)

16. Olejar, "Rockets in Early American Wars" (1946:34)

17. C. Sleeman, "Development of the Machine Guns" North American Review (Vol.139[335], October 1884:370)

18. D.A. Armstrong, Bullets & Bureaucrats (Westport, Greenwood Press, 1982:38)

19. L. Naisawald, Grape & Canister (New York, Oxford University Press, 1960:211)

to innumerable types of ingeniously studded shells that on firing could expand into the grooves of a MLR barrel. (See Appendix 17) Experiments were conducted in an attempt to join ordnance fuse technology with ostensibly obsolete muzzle loading ammunition. The resulting technical development only served to divert effort away from improving the existing BLR designs and their ammunition.

Officials came to consider that there was little advantage in the BLR over the MLR because improvements had still failed to increase the rate-of-fire, overcome problems of barrel fouling, or significantly improve range. On a wider scale however, this example reflects the official inability either to direct technical effort towards more fertile fields, or to look ahead and assess the future potential of some designs.

The Civil War offered the greatest chances for recently devised technologies to be tested in combat. At sea there existed the first opportunity in fifty years for the sustained live testing of weapons and the revising of gunnery techniques.(20) The Naval Yards in both the North and the South permitted new maritime technology to receive a more thorough assessment than could have been expected for land military tools.(21) An example of the successful testing of a design occurred with the John Ericsson "Rodman" 15-Inch cannon and later 13-Inch cannon.(22). Apparently a sound weapon from a skilled innovator using novel manufacturing techniques, the 13-Inch wrought iron cannon used advanced forging techniques which gave greater strength. Nonetheless, the weapon was rejected after extensive tests by the US Naval Bureau of Ordnance showed the forging requirements were too advanced for industry to consistently meet.(23)

Despite some testing success by the Union Naval Department, inspired by the ironcladding of the CSS Virginia, there was still no consistency in US Navy ironclad development. Testing of the Monitor and the first prototype ironclads was almost non-existent. Development was mostly left to trial and error under combat conditions.

The addition of armoured hulls and water-line armour belts to circumvent the Confederate's use of torpedoes became a battlefield development that was later incorporated into Union ironclad designs. Deriving from wartime experience, the US Navy added extra armour to its ironclads. This was the first evidence of a purposeful

20. C. Dixon, Ships of the Victorian Navy (Southampton, Ashford Press Publishing, 1987:8) At Sinope Roads in the Black Sea, Russian rifled cannon destroyed the wooden Turkish fleet. Only one of thirteen in the Turkish fleet survived.

21. A. Hunter-Dupree, Science in the Federal Government (Massachusetts, Harvard University Press, 1957:123-124); B. Anderson, By Sea & By River: The Naval History of the Civil War (New York, Alfred A. Knopf, 1962:291) for Northern yards; & W. Ripley, Artillery & Ammunition of the Civil War (New York, Van Nostrand Reinhold, 1970:110) for the Southern yards.

22. Ripley, Artillery & Ammunition (1970:99)

23. IBID:176

attempt to solve Civil War combat problems through improvements to naval design.(24) This was certainly an advancement over the first two years of the war where the development of ironclads had been a haphazard process that relied on individual commanders making their vessels more battle-worthy.

Development of BLR ordnance was, however, restricted as much by the lack of development in industrial machining as by the preference for smooth-bore cannons in both the North and South. In the South the lack of manufacturing capacity was compounded by a lack of resources which forced the government to import foreign BLR. Industrial problems also affected the North as inconsistent machining techniques prevented the consistent production of quality breech fittings.(25) Despite innovative BLR designs, such as the 7-Inch Brooke Rifle, the Confederacy also had development effort restricted by the knowledge that they still had to rely heavily upon inferior percussion and paper time fuses for their artillery ammunition.(26)

Perhaps the best example of Northern development of a BLR ordnance design is the conversion of the 3-Inch Rodman (Ordnance Rifle Field, M1861) from a MLR to a BLR. After the war this design went on to become the standard field piece.(27) Despite this limited success, the Northern industry faced many problems. Many technologies issued with contracts for production simply were not supplied in time. This severely affected the ability of the US Ordnance Bureau to assess the performance of the more advanced designs, and then apply the derived lessons to future technical developments.

Fuse development during the Civil War is an example of a much more successful field of technical development. Development did not just concentrate on different fuse designs. A wide variety of novel uses for the technology also evolved. Engineers developed basic time and percussion artillery projectile fuses and placed them into hand grenades, land mines and booby traps.(28)

The failure of some fuses to detonate artillery shells, either through poor design or the shell not landing on its nose, necessitated improvement to fuse designs. (Appendix 12) The gradual development of a better fuse and in particular an improved carcass shell design, was marred by the absence of appropriate procurement regulations. With the carcass or 'stink shell', the development of the best design was limited in particular by the lack of feedback from those actually using the best designs. Combat troops options

24. Allard, "Naval Technology" (1989:122)

25. B.R. Lewis, Notes on Ammunition of the American Civil War, 1861-1865 (Washington D.C., American Ordnance Association, 1959:13)

26. IBID:23

27. Ripley, Artillery & Ammunition (1970:162-3)

28. IBID:278; & F.W. Hackley, Report on Civil War Explosive Ordnance (Maryland, U.S. Naval Propellant Plant, 1960:32)

on the choice of the best designs was rarely exercised. They mostly had their choice limited to the design which had actually managed to win the attention of the Quartermaster Department at that particular time. While many similar designs went into production, most had different features and purposes.(29) The front-line troops had no real ability to compare the similar carcass shells to each other or assess how well they performed different tasks. Testing and development of the best carcass shell designs was impossible while the availability of any shell dictated decisions on deployment.

In some cases the testing and development conducted on Civil War technology helped to identify areas for future technical research. Even some very crude designs produced an incremental growth in technical knowledge. Early Confederate submerged river mines had very poor waterproofing, yet they provided the foundation for experimental work that saw later designs address this problem. The benefit of a small change in knowledge could often hold greater meaning for later innovators. This was particularly the case with the development of submarine technology.

The development of the submarine in the South reflected a poor design that reached actual combat use not because of official malfeasance, but more due to desperate military need, hope, and human bravery. At the outset the design for the CSS Hunley was very basic. It was developed with regard for the absence of adequate resources and the builders' inability to construct a system of locomotion. These factors combined to make the submarine one of the crudest military tools to see active service in the Civil War. Yet despite its lack of technical advancement, some wartime contemporaries still believed the development effort was an important precursor for the future:

There seems no insurmountable objection in the way of the construction of a submarine boat; the principal difficulty has been one that ought to be remedied by the application of our increased knowledge of mechanics and chemistry, since the period when it was first conceived – that is, to regulate or purify the supply of air, so as to enable the operators of the boat to remain a considerable time beneath the surface. The general use of torpedoes, offensive and defensive, seems to lead to the introduction and use of such a boat, and it cannot be long before the inventive genius of man will supply the demand made upon it.(30)

Throughout the war, in both the North and the South, there was a significant technical base from which torpedo designs could be devised. However, the lack of experimentation and deployment of more radical designs served to promote only

29. Ripley, Artillery & Ammunition (1970:263–4); J.B. Poole, "A Sword Undrawn: Chemical Warfare & the Victorian Age", (Part I), The Army Quarterly & Defence Journal (Vol.106[4], October 1976:469); & R.V. Bruce, Lincoln & the Tools of War (Westport, Greenwood Press, 1973:237 & 243)

30. J.S. Barnes, Submarine Warfare, Offensive & Defensive (New York, Van Nostrand, 1869:151)

conservative improvements to existing technology. The system of assessment for torpedoes favoured the introduction of those designs which improved on weapons already in service, or could be presented by the innovator as a 'working' model.

Despite wartime developments in torpedo technology the benefits of technological change were not always apparent within the years of the Civil War. In the 1880s one English commentator wrote:

...[the] real power of the offensive torpedo in actual warfare remains yet to be proved, for the few cases recorded during the Civil War in America have by no means settled the point; and many inventions which appear quite successful when tested merely in deliberate experiments, where everything is previously arranged to insure the most favourable conditions, completely fail when applied in actual warfare.(31)

Another weapon that presaged later design success was the Henry repeating rifle. This design was as complex as it was advanced. As such it was both expensive to make with existing machinery and prone to some operational problems. To the foot-soldier, the Henry's higher rate-of-fire more than compensated for any design drawbacks: particularly as the 15 rounds in chamber could be fired in 11 seconds. It was not until the 1866 Winchester lever action rifle, that the true technical promise of the Henry design was more fully realized.(see appendix 22)

Some Civil War innovations were never able to progress beyond the most fundamental level of technical development. The more these new technological entities departed from the weapons already in use, the greater was the difficulty in establishing their usefulness for Civil War combatants. Because they made little or no impact on the conduct of the war, it is difficult to assess how important these technologies were in advancing technical knowledge.

Many innovations were to appear in the Civil War "before their time". In many cases the development that occurred after the war indicated the importance of some innovations. Many of these designs failed to become fully developed only because their potential was not actualized.(32) In general terms this could include the flamethrower, steam-driven land artillery tractors, guided rockets or 'torpedo launchers', and "anti-submarine" cannon devices.

Some of the more interesting concepts that can be examined include the use of aerial photography on balloons, the Dickenson's Steam Gun, and the Lyman accelerating gun.

31. Routledge, *Discoveries & Inventions* (1989:175)

32. This did not necessarily improve after the war, see Armstrong, *Bullets & Bureaucrats* (1982:Chapter 3)

The use of photographic equipment was seen by both aviators and some members of the Academy of Sciences as having distinct advantages.(33) Both photography and aviation were sciences in their infancy. Joined to form a single military tool of unknown technological merit, the concept failed to achieve official support. In retrospect it is possible to appreciate the potential technological advantages that Civil War contemporaries had not appreciated.

Another interesting experiment in an area of which little is known, is the Dickensons Steam Gun, designed by the Confederate supporter Charles S Dickenson.(34) It was also known to the Confederates as the Winans Steam Gun, or Dickensons Revolving Steam Gun. This innovation apparently could throw 300, 2 ounce balls a minute, to a range of 100 yards.(35) The weapon was, however, captured on April 1861 before its development could effectively progress.

In this design the cannon was mounted on a partially armoured steam powered tractor. This design's use of steam traction was not a totally novel military technology. In the Crimean War the British had used the Boydell steam tractor to pull artillery across poor terrain.(36) A British Committee's later investigation of steam traction usage during the Civil War may indicate further Union development on the concept.(37) Did the British have knowledge of further use of armoured steam tractors, or of Union developments in the field? It seem likely that it was the British, rather than the United States, who were more interested in examining the role of steam traction in land warfare. The US Engineering Department acknowledged that, prior to the date of writing in 1899, there was no "instance of the use of road traction engines by our military forces", and nor had they "been seriously considered."(38)

Despite the Dickenson Steam Gun receiving little attention it produced an interesting technical legacy. It can perhaps be considered a legitimate predecessor to the tank, self propelled gun, or even the mechanised combat vehicle. Maybe it should be examined

33. Official Records, (Series 3, Vol.3) (1899:293); & F.S. Haydon, Aeronautics in the Union & Confederate Armies (Vol.I) (Baltimore, Doctoral Thesis, 1941:332)

34. Bruce, Lincoln & the Tools of War (1973:139-141); & B.T. White, Tanks & Other Armoured Fighting Vehicles 1900 to 1918 (London, Blandford Press, 1970:1)

35. F.A. Shannon, The Organisation & Administration of the Union Army (Vol.1)(Gloucester, Peter Smith, 1965:145)

36. The steam road tractor by James Boydell was patented in 1846, and used in the Crimean, however, in 1855 James Cowen recommended the mounting of a gun and armouring a Boydell tractor. See K. Macksey, Technology in War (London, Arms & Armour Press, 1986:21-22)

37. Gallway & Alderson Report 1864, in J. Luvaas, The Military Legacy of the Civil War (Chicago, Chicago University Press, 1959:35-36)

38. O. Layriz, Mechanical Traction in War (London, David Charles Reprint, first published in 1900 - 1973:95-96)

solely as an innovation that indicated more technical promise than could be realistically capitalized on by Civil War contemporaries.

The Lyman cannon is another interesting design that reflects a complete break from existing technology. Despite being based around a patent dating back to Azel S Lyman's patent 3 February 1857, the whole concept of the Lyman cannon was largely devoid of official backing during the Civil War.(39)

At first the weapon was seen as an ideal short range coastal defence weapon capable of delivering torpedoes. The design was based around the use of an exceptionally long barrel with air compression to assist with the gentle build up of a shell's launch, and then the use of charges to accelerate the velocity of the projectile.(40) The weapon may well also have been the first cannon to use an electric firing arrangement.

Future development was to see this "torpedo gun" advanced by Mr Mefford of Ohio in 1883,(41) forming the basis in 1885 to 1887 of the New York based designer Lieutenant Edward Zalinski's Pneumatic Dynamite Gun. This later gun received support as a viable means for both "delivering mines into local waters to supplement the existing defensive minefields", (42) and as a torpedo gun mounted on either coastal stations or on a specially designed boat.(43) The ingenious concept of using additional chambers on a long barrel that could be ignited in succession to increase the velocity of the projectile, was not restricted to just the Pneumatic Dynamite Gun. It later contributed directly to the design rationale behind Herr Conder's World War Two German Cross Channel Accelerating Cannon.(44)

While some designs incorporated technical knowledge that would not be fully developed until many years after the Civil War, it is also possible to identify other innovations that simply drew from past designs. Without actually adding to technical knowledge, these designs produced few advances. Either because contemporary innovators lacked the technical knowledge to improve the design, or because there was no significant addition to related technology, no advance and further improvement could be made on past designs.

39. Ripley, Artillery & Ammunition (1970:176)

40. Added to by Dr. John Brahan Read in a prototype of 1859. This was followed by the Mefford patent, and the Lyman and Haskell British patent 2216 in 1867; see I.V. Hogg & J. Batchelor, A History of Artillery (London, Hamlyn, 1974:204)

41. W.R. Hamilton, "American Machine Cannon & Dynamite Guns", The Century Magazine (Vol.36[6], October 1888:891)

42. Hogg & Batchelor, A History of Artillery (1974:87)

43. IBID:86

44. IBID:204; & Ripley, Artillery & Ammunition (1970:176)

As the naval forces engaged in the Civil War concentrated on improving steam engines, armour plating, stability in deeper water, and fire-power, a direction for world-wide changes in naval construction was confirmed. For all the technological changes Civil War military innovations could draw on, the naval shipbuilders had a limited number of lessons to follow.⁽⁴⁵⁾ With the exception of the HMS Warrior and the French Gloire, the navies of the world were pre-occupied with sail and the wooden walls of a century earlier. Steam and screw propulsion made progress in a remarkably short period of time from 1840,⁽⁴⁶⁾ but the union of these technologies still had to accommodate design features from the past.

The New Ironsides ironclad represents an example of a Civil War design that had few innovative features itself, but simply drew from the Warrior and Gloire, mistakes and all.⁽⁴⁷⁾ It represented an unhappy compromise shipbuilders reached between sail and engine; breech-loading and muzzle-loading cannon; turret technology and the battery configuration; armour and wood or iron plate; and the balance between size against the cost of an increased draught. Coupled with these design dilemmas was the designer's inability to resolve how to increase an ironclad vessel's speed and seagoing capacity, while still retaining a prow ram and large calibre ordnance.

Very early in the development of naval ironclads, American shipbuilders had established from English experiments that a 4.5 inch thick iron plate, backed by teak, would resist the impact of the heaviest naval cannon of the time (the 68-Pounder) at 200 yards.⁽⁴⁸⁾ Yet with improved techniques of gun foundry, especially with the use of a steel inner barrel and the addition of forged iron and wrought iron sleeves, heavier powder loads or increased gun size became possible.⁽⁴⁹⁾

MLR advances necessitated design improvements that would improve both the deployment of these cannons at sea, and protect vessels from their firepower. The value of a BLR cannon that could produce higher impact velocities with a smaller calibre was almost totally ignored. Yet the Civil War did provide compelling reasons for the world's most advanced navies to concentrate on those innovations that would improve firepower and armour.

The inability of either the North or South to produce iron plate more than 1.5 inches thick also provided a brake on efforts to design vessels with thicker armour. Despite

45. Dixon, Ships of the Victorian Navy (1987:1)

46. Routledge, Discoveries & Inventions (1989:101)

47. R. McBride, Civil War Ironclads (Philadelphia, Chilton Books, 1962:68); Official Naval Records, "The Union & Confederate Navies in the War of the Rebellion" (Series I, Vol.15) (Washington D.C., Government Printing Office, 1902:99)

48. Dixon, Ships of the Victorian Navy (1987:3)

49. IBID:4

advances in manufacturing techniques, the problems with producing muzzle-loader cannons of over 68 pounds and mounting them on vessels, effectively limited Civil War naval designer's concentration on increasing armour and armament. All that was gained from the pre-occupation with the combat between heavier armour and heavier solid shot seems to be the diversion of design effort away from resolving problems with ironclad's sea-going capacity. This was to ensure that MLR and MLSB cannon were to dominate American naval arsenals well into the 1880s.

By contrast with the lack of progress in sea-going ironclad design, the Monitor and the David models were responsible for injecting a new life into naval ship design. The Monitor was based around older designs, and highlighted the way subsequent designs could consolidate technical advances. Alternatively, the David used a novel design concept to create a new dimension in naval warfare. These vessels both formed a significant basis for fundamental additions to existing technical knowledge on shipbuilding.

The wartime use of the telegraph and railroad technology also stand as examples of pre-war technical knowledge being applied in a novel manner. Concentration on completely new technical advances was less evident than attempts to improve the military utility of existing technology. In the South this lack of innovative effort may be traced back to the continued lack of resources necessary to produce rail and telegraphic equipment. However, in the North, technical advancement actually became subservient to making the existing technology suit combat requirements. Design development lagged behind the need to improve the immediate utility of the technology for field operations. This is not a condemnation of innovative effort. The ability to utilize "telegraph trains", and the linking of aerial observation with telegraph communications, provided an indication of the importance front-line military communications could play in future wars.(50)

Similarly, in the field of medicine, technical advancement seems to have been limited by the absence of further breakthroughs in developmental research that could have altered wartime practices. Improvements in management and understanding increased the utility of medicine as an organised body of technical knowledge. But technology reliant on past knowledge needed breakthroughs in pure or applied research to fundamentally advance its wartime utility.

50. Official Records (Series 3, Vol.3) (1899:293)

MILITARY TECHNOLOGICAL CHANGE AS AN ENVIRONMENTAL FUNCTION

Fundamentally, an institutional framework for the encouragement of specific innovations was never formally devised during the Civil War. Military and government administrative bodies responsible for nurturing military technological change became centred on controllable technology. This situation was due to environmental factors ensuring that the developers of Civil War military technology acted in virtual isolation from each other. Because individuals operated on particular technologies, without exact knowledge of all design work in the technical field, final technological changes were assessed on their individual merit. The process of adoption became very competitive and rarely subject to evaluation by officials in possession of the full knowledge of each design's relative technical merits.

There was clearly only a limited capacity for any wartime government to speed wartime technological development by intervening in the private sector. Additionally, current debate over the effect of the war on industrial production precludes any categorical statement that the war provided the catalyst for a massive gearing-up of productive capacity. Nor, finally, may we either indicate that society was responsible for removing barriers to military technological innovation, or formal institutions were capable of deliberately nurturing the most promising new technologies.

The delays between innovation and formal support, therefore, were determined not by the effectiveness of the new technology, but by the capabilities of the supervising institution. A study of some specific organizations illustrates that regardless of the technology's inherent benefits, institutional inertia obstructed innovative effort. Quite simply, organizational practices and subsequent reforms, could not cope with either the rapidity, or the diversity, of changes to military technology.

Even where bodies were established to encourage known, low-risk technological change, such as railroads, organizational problems restricted developments. As with the Quartermaster Corps, the administrative power of an institution did not mean that it would necessarily encourage innovation. Nor did the Engineering Corps' lack of a specific charter or direct influence in technical developments prevent it from playing the role of catalyst in the encouragement of military innovation.

In essence the major problem limiting the promotion of innovations by Civil War organizations was the failure to give those with technical know-how sufficient autonomy. Civilians' technical knowledge was subjugated to military authority. Working outside the direct supervision of the military meant that many innovators had

to labour without the assistance of any clear statement on current or future military needs. Without clear institutional guide-lines, innovators realized that designs had to be based on established technology (with benefits known to military commanders) if they were to be adopted. Without the endorsement of army Head Quarters or High Command figures, the chances of utilizing new technology, or replacing old technology with new, were remote.

The initial restriction on introduction of small arms innovations, the demise of the Balloon Corps, the restricted success of the Telegraph Corps, and barriers to the work of the Sanitation Corps, all reflect the lack of technology-specific encouragement from the Northern administration. Without the co-ordinated endorsement of formal institutions, the systematic introduction of innovations was not possible.

PART III

THE LEGACY OF MILITARY TECHNOLOGICAL CHANGE IN THE CIVIL WAR

INTRODUCTION

For the American Civil War to be accurately labelled the "last of the old wars and the first of the new",⁽¹⁾ military technology must be shown to have gone through a tangible and sustained change; it must have progressed beyond that of previous eras.

After surveying many types of technical innovations, as well as examining environmental factors, it is possible to perceive a number of important features of military technological change in the Civil War. It appears that innovations in military-related technology occurred in key areas. Subsequently, however, it has also been established that institutional support and government encouragement did not actively promote the rapid assessment or adoption of the most promising of these innovations. Thus while important technical innovations may be identified, restrictions limited the impact these designs and ideas could have.

To establish more fully the impact of Civil War innovation, it is necessary to outline the lasting impact technological change had on wartime strategy and subsequent military engagements. The fact that the next chapters are outlining, rather than establishing any conclusions, is indicative of certain inherent problems. In conducting this study it is necessary to realize that the significance of military technological advances were not always apparent to those participating in the war. Additionally, while there is obvious merit in understanding the future impact of the "Civil War legacy" on subsequent wars, the coverage of all post-war influences is a massive undertaking. Certainly scholarship on the theme of lessons derived from the war, whether they be strategic or technological, has been shown within the earlier historiographic section of this thesis, to be enormous. Equally, it is open to revision and interpretation beyond the scope of this thesis' immediate technical concerns.

The final chapter of this section endeavours to place wartime military technological change into an overall perspective. As has been postulated in chapter 1, if a hypothetical model of the Civil War innovation process may be drawn, then conclusions regarding the general growth in technical knowledge may be made.

1. H.S. Commager, The Blue & the Grey (Vol.I) (Indianapolis, Bobbs, 1950:xv)

CHAPTER 8: THE IMPACT OF TECHNOLOGICAL CHANGE ON WARFARE DURING THE CIVIL WAR

Precursors in the change to military hardware had been in evidence prior to the Civil War. In particular, the period immediately before the war was marked by developments in railroads, the telegraph, construction techniques used to make heavy ordnance, new designs of breech-loading rifles, and the evolution of the repeating rifle. By the end of the Civil War it was these same technical developments that were to be acclaimed as the best innovations. But were these changes so important? Does the failure to fully exploit such innovations as the breech-loading and repeating rifles, balloons, rockets, stink shells, and other innovations, negate the overall impact technological change had? Can the use of railroad and telegraph technology be held as the quintessential representatives of successful wartime innovative effort?

In itself the deployment of a technology is only part of the technological change story. It is also very important to understand how key innovations succeeded in re-shaping traditional warfare.

8.1 Impact of Innovation on Land Warfare

General Sherman of the United States Army believed that the changes to "artillery, engineers, ordnance and staff" and "the scientific branches of the military service" had lifted the art of war to a strategic level where it could be considered no less than a science of war.⁽²⁾ To General Sherman the "science of war" is the underpinning capacity of an army to deploy technology effectively. Sherman believed this advance changed the capacity of the Union forces to wage war.⁽³⁾

The introduction of new weapons technology changed the simple art of war to such an extent that General Phil Sheridan (US Army) believed "nations could not make war, such would be the destruction of human life."⁽⁴⁾

From a strategic perspective, the Civil War had many unique characteristics that were to remould military tactics, even before military innovations came to impact on the war. There existed a mass conscripted army of a size, configuration, and mobility unparalleled in contemporary wars.

2. W.T. Sherman, "The Grand Strategy of the Rebellion" *The Century Magazine*, (Vol.35[4], February 1888:597 & 582)

3. In this sense the "science of war" is not referring directly to the establishment of a scientific body of knowledge relating to weapons development.

4. Quoted in R.V. Bruce, *Lincoln & the Tools of War* (Connecticut, Greenwood Press, 1973:298-299)

Although tactical units of war were still based around the 500 to 1000-man units common to the Napoleonic Wars,(5) they carried unique features. This included regiments made up of regional groups of volunteers, few of which had experienced officers (6) and which often had a level of intelligence and physical fitness, below that expected of regular soldiers.(7) Yet these loosely organised and poorly commanded units were expected to be mobile, to fight over rough, wooded terrain, and to do battle in sustained campaigns.

When listing the important strategic phases of the Civil War, six basic periods can be identified:

- (i) Washington to Richmond battles 1861-62.
- (ii) Union consolidation of lines 1862.
- (iii) Confederate counter strokes (Lee & Jackson).
- (iv) Union Offensive, 1863-64.
- (v) The war of attrition by Grant and the defensive war fought by Lee 1864-65.
- (vi) From 1862 until 1865 the presence of guerrilla raids and tactics used by both sides.(8)

Although both sides' strategic phases were not necessarily as systematic, the above description serves to illustrate certain trends in tactical operations. One of the most profound strategic trends was the shift from offensive tactics, to an increase in the importance of defensive tactics. As military technology changed, there continued to be a re-examination of the tactics used by fighting units. In the rough terrain and on the battlefields that spread over hundreds of miles without front lines, the trend towards irregular warfare increased.

From 1861 to 1863, the war was marked by the inconsistent tactics used by land forces. In 1861 the Union army in Virginia went from one disaster to another, yet consolidation of command, organisation, and supply, saw Union land forces reach a level where military operations could be more offensive. However, from mid-1862 until 1863 the impetus of the Union army yielded to the superiority of the South's defensive

5. J. Coggins, *Arms & Equipment of the Civil War* (New York, Double Day, 1962:21)

6. M.C. Meigs, "On the Conduct of the Civil War", *American Historical Review* (Vol.26[2], January 1921:285-303)

7. F.V.A. De Chanal, *The American Army in the War of Secession* (Kansas, Spooner, 1894:43-440); & F.A. Shannon, *The Organization & Administration of the Union Army* (Vol.I) (Massachusetts, Peter Smith, 1965:156-167)

8. Wolseley (Viscount), "An English View of the Civil War", *North American Review* ((Vol.148[390], January 1889:538); & L.C.F. Turner, "The Grand Strategy of the Civil War", *Australian Journal of Politics & History* (Vol.26[1] 1980:57-70)

positions.(9) Through the deficiencies of Union strategists, the war, by 1863, had become a war of attrition.

A number of technical developments underpin the course of the war's strategies. Most importantly, the superiority of rifled small arms in defensive positions limited offensive operations. This was coupled with developments by both sides in observation balloons supporting over-the-horizon rifled artillery fire, field telegraph systems, and well constructed field fortifications. Defence by both sides settled into immobile and unmovable front lines. Trench warfare became symbolic of the 1864-1865 campaigns. The siege of Petersburg itself is the epitome of the period and a most familiar precedent to the battles of the First World War.(10)

As weapons reinforced defensive tactics, so they also served to promote tactical changes. A new system of infantry tactics was devised to avoid the destruction new small-arms wrought on troops attacking with line in-depth formations. Double and single ranks were adopted by the Union army to manoeuvre troops through difficult terrain. When in frontal attack, swarms and skirmishes replaced columns and ranks.(11) These tactics were further enhanced by the use of breech-loading and repeating arms that enabled men to fire and load in a prone position or to reload on the run.

The "epoch in the history of tactics"(12) was to extend to the way generals deployed troops. Debate has long raged over the lack of sound strategic development in the Civil War and over who, of the few good leaders, was the best general. While the merits of Generals Grant, Lee, "Stonewall" Jackson, and Sherman, are widely debated, their strengths provide invaluable insights into important tactical developments.(13) Strength lay in Lee's defence, in Grant's retaining the initiative in offensive operations during 1864-65, and in the fluidity of Jackson's and Sherman's tactics and strategies.

The characteristics of these generals have been used to illustrate the importance of defence in twentieth century warfare. Their actions confirmed the importance of attacking an enemy through the commitment of men and resources at his weakest point, and the commitment to total warfare that attrition forced into being.(14)

9. W.H. McNeill, The Pursuit of Power (Oxford, Basil Blackwell, 1983:242)

10. Although the poor use of company level tactics and the deployment of mass formations has been identified by Paddy Griffith as not making this battle, or the Civil War, any different from Napoleonic wars. See Rally Once Again: Battle Tactics of the American Civil War (Wiltshire, Crowood Press, 1987:189 & 191)

11. I.B. Cohen, "Science & the Civil War", Technology Review (Vol.48, 1946:167-168)

12. F. Maurice, Robert E. Lee (New York, Houghton, 1925:290-291)

13. J.F.C. Fuller, The Generalship of Ulysses S Grant (New York, Dodd - J. Murray, 1929); B.H. Liddell-Hart, Sherman the Genius of the Civil War (London, Dodd, 1930); & A.H. Burne, Lee, Grant & Sherman (London, Scribner, 1938)

14. Turner, "Grand Strategy" (1980:60); E. Hagerman, The American Civil War and the Origins of Modern Warfare (Bloomington, Indiana University Press, 1988:207-209); T.H.

Civil War generals attributed few lessons to their predecessors' tactics. General U.S. Grant did not underrate the value of military knowledge but he attributed little merit to comparing the strategic lessons Civil War generals could gain from pre-war European writers.⁽¹⁵⁾ Clausewitz's lessons had not been extrapolated and he remained almost unknown; Jomini became less relevant as technical innovations saw the decreasing use of cavalry and shock tactics; and Wellington, Napoleon, and Marmont were dated. General Sherman believed their lessons applied *post facto* to events:

As we won the battle, we are willing to give these authors the benefit of our understanding.⁽¹⁶⁾

These words reflect the general's certainty that strategic management of the war was uniquely indigenous. The truth, however, lay closer to the fact that mid-nineteenth century military writers were applied by those post-Civil War analysts who sought to interpret the war's strategic lessons. Poorly trained troops and poor terrain negated European tactical principles. The advent of rail, telegraph, and breech-loading and rifled ordnance technology, altered the validity of new tactics devised in early and mid-nineteenth century Europe.

Before rifled cannon, small-arms, and in particular prototype rapid-fire guns, the Napoleonic rigid line and column tactics yielded to more open formations.⁽¹⁷⁾ Troops also began to dig in as a normal means of protecting themselves from longer range, more accurate rifle and artillery fire. The art of field fortifications became a major part of armies' static defensive positions.

Eventually this process of tactical improvisation led to a strategy of exhaustion. The strategy of exhaustion was pursued with the Union confident in its ability to use industrial strength to crush the Confederacy, and the South countering with the defensive tactics of General Lee. The process of attrition seems to have evolved from meeting of these two antagonistic strategies. The Northern leaders,⁽¹⁸⁾ were obliged to try and force defeat upon the South, and draw the South from its defensive positions. From late 1863, it could be argued, that the South was hoping the Northern society's resolve for the maintenance of war would falter.

Williams, "The Military Leadership of the North & South", in D. Donald (ed), Why the North Won the Civil War (Louisiana, Louisiana University Press, 1960:33-54); & R.E. Beringer, H. Hattaway, A. Jones, & W.N. Still, Why the South Lost the Civil War (Athens, University of Georgia Press, 1986:18-20)

15. In Donald, Why the North Won (1960:6)

16. Sherman, "Grand Strategy of the Rebellion" (1888:583)

17. D.G. Chandler, Atlas of Military Strategy: The Art, Theory & Practice of War, 1618-1878 (London, Arms & Armour, 1980:129)

18. J.B. Fry, "Lord Wolseley Answered", North American Review (Vol.149[397], December 1889:731)

Tactics became shaped to each battle's peculiar situation. When Lee's defensive tactics and Grant's battering ram style offensive tactics met in a battle, all available resources were used to gain victory. These conflicts foreshadowed the total wars of the twentieth century – the types of battles where nations threw their industrial, political, and economic force behind military objectives; battles where nations' civilian populations could not feel isolated from the impact of war.

General Sherman's push to the sea reflected the attack on strategic rail lines, economic resources of the South, and more importantly a challenge to the Confederate States' will to maintain a war against an aggressive enemy.(19) Into these strategic imperatives, innovations injected both a means with which to sustain a war of attrition, and a means to inflict greater injury on the opponent. Technical developments altered the means by which battles could be fought. They also changed tactics as some innovations added new dimensions to warfare.

Rail in particular still stands as an example of an innovation that never had its strategic potential realised. Viscount Wolseley pointed out from his witnessing of the operations at Manassas Junction during the battle of the First Bull Run that:

It is clear that, essentially, this railway movement was purely one of general reinforcement.(20)

This observation was to reflect the general use that rail was put to during the war. Wolseley attributed this limitation in use to two major factors: the lack of sidings into which lower priority reinforcements could go to enable essential rail traffic to get through, and the tactical naivety of the generals, who lacked command of the lines and an awareness of how rail could bring troops to an enemy's flank.(21) These factors were to influence the American Army's use of rail throughout the war and beyond.(22)

The failure to control the introduction and use of railroad technology severely limited how successfully they were deployed. Chapter 6 highlighted how the use of rail ostensibly became divided between the US Military Railroad Department – which employed civilians with the necessary technical expertise – and military commanders who possessed a number of unco-ordinated tactical priorities. Field commanders became responsible only for the protection and local operation of railways. While the maintenance of rail roads, logistical priorities, and overall control of rail lines remained in other hands.

19. Hagerman, The American Civil War (1988:207); & Beringer (et al), Why the South Lost (1986:246–247)

20. Wolseley, "An English View", (January 1889:560)

21. IBID:559–560

22. R.H. McLean, "Troop Movements on American Railroads During the Great War", American Historical Review (Vol.26[3], April, 1921:464)

Field commanders' need to move troops and logistics effectively, became mutually exclusive.(23) The use of rail by the field commanders of both sides was compounded by the lack of available rolling stock. For strategic reasons, then, the emphasis was placed on denying the enemy the use of his rail lines. The full exploitation of railroads as a means to move troops to advantageous positions never assumed a dominant role in the Civil War field commander's options. The story of the Civil War railroads is thus an example of how new technology can be put to use fulfilling vital functions, yet fall short of achieving its full military potential in these areas. Inherent organisational problems, and commanders' tactical short-sightedness circumvented attempts to foster the strategic use of railways.

The position of the telegraph as a technical innovation that greatly assisted in managing field operations is a little more secure. Although used in the Crimean War, it was during the Civil War that the electric field telegraph achieved its greatest success as a command and control tool. Spread across wide spheres of action and with massed armies involved, Civil War leaders quickly utilised the telegraph. It was particularly useful in relaying orders and commands between commanders and statesmen, or commanders and men on the front line. The strategic control of massed armies was, therefore, significantly enhanced.(24)

However, the telegraph's potential as a tactical tool was not fully realized. Innovation on the basic design allowed smaller, mule-pack field telegraphs which added a new dimension to army communications. Its use revolutionised logistical supply by effectively bringing the supply bases closer to the front.(25) But these more mobile field telegraphs were seen more as tools for enhancing executive commanders' communication, rather than field commanders' control over field units. Contemporary perception of the overall success of telegraphic technology was limited to its ability to make the battlefield closer to executive commanders. Technical gains in field telegraphic communication systems were not exploited to a point where its full value as a command tool could be realized.(26)

After qualifying the strategic success of railroads and the telegraph it should not be assumed that their importance has in any way been reduced. In fact, the qualifications

23. This was particularly the case at Chickamauga. The Confederate forces took over a week to organize the transportation of troops to the battlefield, so losing valuable strategic advantage. The Union forces, however, had problems just supplying their forces. M. Howard, The Franco-Prussian War (London, Rupert-Davis, 1962:3); & G.E. Turner, Victory Road the Rails (Connecticut, Greenwood Press, 1972:45)

24. W.R. Plum, The Military Telegraph (Vol.I & II) (New York, Arno Press, 1974)

25. Meigs, "Conduct of the Civil War", (1921:296-297)

26. R.W. Donnelly, "Rocket Batteries of the Civil War", Military Affairs (Vol.25, 1961:69-70)

made here stress the fact that as innovation occurred in their use and design, the latent technical potential of railroads and telegraph was not necessarily increased correspondingly. Many of the shortcomings in their use rested on the inability of institutions or individuals to adapt quickly to introduced changes.

Designs did not have to be perfect on introduction for there to be advances in technical knowledge. In turn these technical advances could profoundly influence Civil War combat. The introduction of rifled small arms caused a number of tactical changes on the battlefield. Battle-lines stretched, armies formed for assaults further apart, the density of men in the battle zone reduced, and shock actions became decidedly subordinate to fire-fights.(27)

As the range and firepower of rifles increased, new dimensions to warfare were consolidated. Shock tactics were devastated by frontal defensive fire.(28) Cavalry had their lances and sabres replaced by repeating carbines and revolvers. The weapons range, accuracy and rate-of-fire was further promoted. Weapons such as the Sharps breech-loading carbine, Spencer repeating rifle, and Gatling Gun proved desirable weapons in the new era of destructive capacity. They linked the power of technology change with the capacity to wage devastating warfare.(29)

Other technical developments confirmed the importance of technological change by giving warring sides unknown advantages. Developments such as balloon technology, medicine, rockets, land torpedoes, stink shells, and others, presaged strategic dimensions of warfare that had not been remotely comprehended by Civil War generals. For some innovations the war would only be a stepping-stone in their long evolution.(30)

The story of key wartime developments in rocket, stink shell, heavy artillery, weapons sights, grenades, and explosive ordnance is marked by their mixed success. All these weapons were to be the basis for experiment. For designs like rockets and heavy artillery, the wartime innovation by both sides was founded on pre-war research. Consequently, development tended to be restricted more to perfection of existing designs, without particular regard for the technical changes necessary to make them better able to meet strategic needs.

27. J.K. Mahon, "Civil War Infantry Assault Tactics", Military Affairs (Vol.25[2], Summer 1961:59)

28. N. Malcolm (ed), The Science of War (London, Longmans, Green & Co., 1910:1 & 339); & Coggins, Arms & Equipment (1962:24)

29. W.R. Hamilton, "American Machine Cannon & Dynamite Guns", The Century Magazine (Vol.36[6], October 1888:885)

30. This was particularly the case for the Gatling Gun see D.A. Armstrong, Bullets & Bureaucrats (Westport, Greenwood Press, 1982:76-77)

One technical development that never had its strategic potential fully attained in Civil War combat was the hollow shell. As a means of conveying chemical substances, this device produced a whole range of novel developments. The success of these shells, when deployed by the North as phosphorous anti-town shells or stink anti-personnel weapons, was not converted into wider deployment. The ultimate recognition of the stink shell's design integrity can only be acknowledged by noting that First World War gas shells differed little from the Civil War hollow shell design principles.

The success of heavy artillery, grenades, and other wartime innovations may not necessarily be due to their designs. Often circumstances in the war permitted poor innovations to achieve close to their full potential. When compared to the First World War's steel and iron breech-loading artillery, the Civil War's basic wrought-iron muzzle-loading cannons were technically still in their infancy. Other weapons such as the hand-grenade, which was successfully used in the war, were still basically crude designs. The 6-pound "winged" Ketchum grenade was certainly cumbersome and lacked the design efficiency First World War trench warfare would encourage. Land torpedoes or land mines, although effective in the American conflict, were also to be refined in future wars.

That a wide range of technical innovation did occur, is not disputed. There is no absolute reason why these new technologies should have produced strategic changes. Some technically advanced innovations had potential to change the conduct of war but were never to produce a significant impact (eg. the stink shells). Regardless of this, certain other innovations did produce significant reconsiderations of land tactics, even before they had been technically refined (eg. the BLR technology).

Before tactics could change to match new technological capabilities, there had to be recognition by field commanders, that new dimensions had been added to land engagements. This is exemplified in a battle at Chickamauga in September 1863. Longstreet's confederate cavalry and men charged across open fields to assault Wilder's Lightning Cavalry Brigade. Armed with Spencer repeating rifles, Wilder's men were dismounted and under light cover of trees and ditches. Under the Spencer's fire, wave after wave of Longstreet's men "...appeared to melt or sink into the earth".⁽³¹⁾ On the third day of Gettysburg, the lesson was again repeated. Pickett's charge (2 July 1863) consisted of 15,000 men, yet only 150 reached Cemetery Ridge. Caught in the crossfire of rifled weapons from 300 metres onwards, they were annihilated.

General Sherman's belief in the "science of war" may not only reflect his own perception of how warfare had changed but reflect the increased need for field

31. Bruce, *Lincoln & the Tools of War* (1973:285)

commanders to identify the strategic advantage of those military innovations being encountered.

8.2

The Impact of Innovation on Naval Warfare

Civil War technological change made a profound contribution to naval strategy. As the most prominent example of a naval engagement, during a time when naval conflicts were scarce world-wide, the war stood as an example of how rapid industrialisation and technological advance could influence naval weaponry.(32)

The basic naval strategy adopted by the North was so fundamental and well established, that innovations only arose from the need to meet strategic imperatives. The impact of innovations on tactics, however, may be discerned. The strategic master plan set for the Union's navy was:

- (i) the consolidation of the blockade, 1861–62
- (ii) gain control of the rivers, 1862–64
- (iii) offensive against coastal ports, 1862–65, and
- (iv) naval war of attrition, blockading the South and splitting the South down the Mississippi, 1862–65.

Changes to the tactics used to achieve these aims arose from the introduction of steam propulsion, armour plating, turret mounted cannons, and large-calibre guns. These changes to technology quickly showed their dominance over older sail and wooden vessels in coastal engagements.

During the American conflict steam power was extended beyond industry and applied to war; steam power and armour-plating on ships were combined to deadly effect. At the battle of Hampton Roads, these innovations were to establish a new era in naval warfare. The lessons learnt there, and repeated throughout the war, signalled the end of traditional sail-powered and wooden-constructed front-line fighting vessels.

During the war, other innovations successfully secured their places as effective naval weapons. In particular, semi-submerged and submarine warfare carried out by torpedo, and torpedo-related technology, established themselves as indispensable offensive and defensive tactics in contemporary naval conflicts.

Naval innovations grew upon a sound base of technical expertise that was intentionally designed to perform critical functions. Although pre-war innovations and the early

32. E.B. Potter & C.W. Nimitz (eds), Sea Power (New Jersey, Prentice-Hall, 1960):326)

wartime developments were often poorly designed, they did at least indicate, under combat conditions, the areas for more successful naval technical advancement.(33)

As seen in chapter 3, ironclads of the Civil War were far from a revolutionary discovery. They were based on experiments in steam propulsion and the use of iron armour in warship construction that had been conducted in America and overseas since the early 1840s. Before the war, American naval engineering had also possessed a reputation for producing sound innovative designs in related areas.

The Civil War was to be a testing and developmental stage in American naval warship design. During the war, ironclad designs confirmed the superiority of armoured warships over traditional unarmoured wooden warships. The war also served to test the ironclad's design features. Although John Ericsson had been accused of copying his design from the overseas designs of La Gloire and HMS Warrior, which pre-dated Civil War ironclads, the Americans were responsible for the first battle-testing of these innovations.(34)

The ability of large-calibre weapons to effectively engage targets at longer ranges was also demonstrated. More explicit evidence was given on how an armour-plated vessels could withstand most forms of attack, whilst inflicting grievous damage to unarmoured vessels. This was even developed to a stage where ironclads could close with the enemy to point-blank range, and survive.(35) Ironclads were felt to be almost impervious to ramming, direct fire, or any other form of attack.(36)

The example set at Hampton Roads, and repeated throughout the war, showed that ironclad technology included a number of innovations that proved the maritime supremacy of defence over offence. Most importantly, the superiority of an ironclad ram's ability to sink a wooden vessel was illustrated when the CSS Virginia used her new prow ram and sunk the USN Cumberland. To Civil War contemporaries this confirmed that while innovations threatened the wooden and sail principles of traditional naval design, modern warships had to adopt new technology to be effective strategic weapons in the future.(37)

33. L.M. Pearton, "The Princeton and the Peacemaker", Technology & Culture (Vol.7[2], Spring 1966:182)

34. Blackwoods Edinburgh Magazine Editorial, (Vol.2, 1860:616-649); & Blackwoods Edinburgh Magazine (Vol. 9 [560], 1862:787)

35. E. Holdern, "The Albemarle" & the Sassacus An Attempt to Run Down an Iron-Clad with a Wooden Ship", The Century Magazine (Vol.36[3], July 1888:430-432)

36. "Career of the Albemarle" in Century Magazine Vol.36[3], 1888:420-438)

37. J. Whitworth letter to the Editor of The Times 5 April 1862, in H. Brogan (ed), The American Civil War: Extracts From The Times, 1860-1865 (London, Times Books, 1975:69); & United Service Magazine, Naval & Military Journal, "Ordnance Versus Iron Plate" (Part I, No.407, October 1862:289-90)

As technology changed, it did not necessarily directly alter strategy. In fact, in the naval war, strategy often dictated the course of technical developments. The emphasis on inland waterways and coastal warfare increased the importance of shallow draught ironclad designs. In turn, the use of ironclads mounting heavy-calibre smooth-bore cannons necessitated a re-evaluation of coastal forts, and both their construction and the types of heavy ordnance they mounted, became the subject of change during the war.

American ironclad technology integrated many technical advances made in the course of the war. The incorporation of these innovations enhanced the specific operational and functional success of ironclad designs.

Both sides quickly developed and introduced vessels that were purposely built on the principles of ironcladding, steam propulsion, and protected heavy calibre cannons.(38) Later combat experience demonstrated that large calibre cannons had little ability to pierce sloping, inch-thick iron plate with strong wooden backing. Experiments were also made in the North with ironclad hulls to protect against mines, armoured decks to protect against high trajectory ship-mounted mortars, and better stability to increase the seagoing performance of ironclad warships.(39) Attempts were also made to increase the speed and manoeuvrability of inshore or river vessels.

An important influence on the successful utilization of ironclad technology was the mounting of large-calibre cannons on naval vessels. As ironclads reduced the effective power of small calibre cannons at sea, and as navies sought to engage land targets at long ranges, the importance of heavy ordnance increased. The pre-war Rodman and Dahlgren rifled smooth-bores provided the basis for Civil War innovation. These guns produced the central focus for the attempts to arm warships with a variety of calibres over 8 inches.

Despite the larger calibres, the development of rams occurred because solid shot could not sink ironclads. The decline of masonry coastal fortifications and the introduction of low-profile forts with thick walls, protected by like designed large-calibre rifled smooth bores, was also instituted to improve coastal defence against new large-calibre sea-borne naval cannons.(40)

38. M.X. Raymond, "The English & French Navies", United Service Magazine & Naval & Military Journal (No.406, September 1862:50)

39. Admiral Farragut in V.C. Jones, The Civil War At Sea (Vol.III) "July 1863–November 1865 – The Final Effort" (New York, Holt, Rinehart & Winston, 1962:240)

40. United Service Magazine, Naval & Military Journal, "New Guns Versus Old Fortifications" (Part I, No.407, October 1862:198–208)

Although large-calibre smooth-bores were successfully built using new casting techniques and better designs, little advance was made in breech-loading designs. Thus while American innovators were striving to build larger calibre smooth-bores that could fire heavier shot to crush and shatter iron plating, makers in Britain were proving the importance of high-velocity cannons.(41) In Britain, tests had shown that:

Heavy shot and high velocity – in other words, heavy shot and heavy charges of powder – will smash through even six-inches of plates like glass.(42)

Trials in Britain had demonstrated that increased muzzle velocity, plus breech-loading and rifling, could increase projectile velocity without the need to increase charges. This technical knowledge was soon adapted to self-contained ammunition in smaller-calibre cannons. (In fairness to contemporary American military officials, one must note that the British themselves adhered to muzzle-loaders until the 1880s, in defiance of the results from these trials.) Although possessing the breech-loading and rifling technology to create high-velocity large ordnance, the Americans adhered to designing larger muzzle-loaders that added shot weight and permitted increased powder loads.

Adherence to the principles of muzzle-loading ordnance technology permitted episodes like the survival of CSS Tennessee and CSS Albemarle in confrontations with superior Northern fleets.(See also Appendix 25) History records the survival of ironclads that were hit by more than 50 heavy-calibre shells.(43) It is important to recall that it is doubtful whether rifled ordnance would have proved any superior to the large calibre smooth-bore Dahlgren cannons given the close range over which most Civil War ironclad engagements occurred.(44)

The success of naval heavy ordnance was due mostly to its effectiveness in the war and not to its innovative technical merits. While tactics remained centred on ramming and close-quarter engagements, the role of existing weapons was not challenged.

The story of torpedo technology followed a similar course. The torpedo cannot be said to have altered the course of any naval engagement or to have achieved the level of design integrity that their early innovations promised.(45)

41. J Whitworth letter to the Editor of The Times 5 April 1862, in H. Brogan (ed), The American Civil War: Extracts from The Times 1860-1865 (London, Times Books, 1975:69); & USM Journal, "Ordnance Versus Iron Plate" (1862:289-90)

42. Trial of the 12-pounder Whitworth field gun and & 70-pounder Naval gun at 200 yards, USM Journal, "Ordnance Versus Iron Plate" (1862:289)

43. R. McBride, Civil War Ironclads (New York, Chilton Books, 1962:30-31)

44. D.C. Allard, "Naval Technology During the American Civil War", American Neptune (Vol.49, 1989:116)

45. M.F. Perry, Infernal Machines (Baton Rouge, Louisiana State University Press, 1985:196)

The torpedo's impact on Civil War naval operations can be discerned from the records of naval engagements. In effect, by denying free access to rivers and defended ports, torpedoes produced immeasurable (more supposed by the Northern commanders than historically apparent) restraints upon Northern tactical operations against the South. This permitted the South to create indecision in Union naval commanders' minds. In the Mississippi and James Rivers, at Charleston and numerous other Confederate coastal ports, torpedoes deployed by the South were able to reinforce its defensive capacities significantly, even though its forces were vastly inferior to the attacking Union forces.(46)

Torpedoes certainly altered the mass fleet operations used to support combined operations against Confederate coastal bases. Single line formations became preferred.(47) These rudimentary torpedoes were deployed in submerged or semi-submerged batteries that effectively deprived northern vessels access to narrow, shallow stretches of water. In no small way, torpedoes permitted the South to delay the Union navy's attempts to split the Confederacy down the Mississippi River and blockade coastal ports.(48)

Design development of the torpedo never progressed at the speed early innovations indicated. In the South, shortages of resources and the immediate need for torpedoes, restricted production to a few designs with other more ingenious innovations mostly left on the drawing-board. In contrast, the Union production was limited more by moral concerns about the "civilised" nature of deploying torpedoes in warfare. Coupled with this were two other concerns. Fears were held by commanders that torpedoes would undermine ironclad technology if they became widely accepted as legitimate weapons.(49) The North also apparently felt torpedo technology was mainly for offensive use, rather than for use as a defensive weapon. The effect of torpedoes on ironclads has been well-documented but the successful offensive use of torpedoes is often under-rated.

Development of offensive torpedo technology was centred on the use of torpedo-boats and submersible vessels. These developments must stand as one of the more successful innovation stories in the Civil War.

46. IBID:4; & F.A. Parker, The Battle of Mobile Bay (Boston, A. Williams, 1878:26)

47. Admiral Farragut in Parker, The Battle of Mobile Bay (1878:See Attached Chart)

48. Jones, The Civil War At Sea (Vol.I) "January 1861-March 1862 - The Blockaders" (1960:vi)

49. Jones, The Civil War At Sea (Vol.III)(1962:60)

The development of the torpedo-boat centred on the South's semi-submersible David and Squib type vessel, and the North's Cushing type launch.(See Appendix 13 & 14)(50) The David class' success in operations around Charleston belied its humble beginnings. General Beauregard, commander of Charleston's defence wrote:

I fear not to put on record now, that half a dozen of these 'torpedo rams', of small comparative cost, would keep this harbour clear of four times the number of enemy's iron clad gunboats.(51)

The success of the David and Squib deeply affected the Northern commanders. Even the Northern Secretary of State, Frederick W Seward, was moved to issue a directive to maintain the safety of the fleet in this new "age of steam and torpedo".(52) The Northern fleet commander, Rear Admiral John A Dahlgren, reported on the operations of the David that:

Among the many inventions with which I have been familiar, I have seen none which acted so perfectly at first trial...The secrecy, rapidity of movement, control of direction, and precise explosion indicate, I think, the introduction of the torpedo element as a means of warfare. It can be ignored no longer.(53)

Northern development of the torpedo was consolidated within a few years. Its most noted success occurred when it was used as an offensive weapon by Lieutenant Commander W B Cushing, who, using a steam launch with a spar torpedo, rammed and sank the CSS Albemarle on 27 October 1864.(54) Further advancement of the torpedo-boat followed this success. Within a few months the North had constructed the first purpose-built MTB (motor torpedo-boat), and by war's end had firmly fixed this technology into the ranks of the world's major navies.(See Appendix 15)

Of significant note was the development attempts by both sides and, in particular, the desperation shown by the South, to create an effective submarine torpedo-delivery vehicle. Testing and development of this vehicle was to confront innovation problems that few would have attempted to resolve in peace time. Yet the vessel that was to go down in history as the first submarine craft to successfully sink an enemy's ship, was both a crude and inefficient design.(55) Nevertheless, the design refinements and

50. W.B. Cushing (Commander USN), "The Destruction of the Albemarle" (Part III) of "The Career of the Confederate Ram Albemarle", The Century Magazine (Vol.36[3], July 1888:432-438)

51. Jones, The Civil War At Sea (Vol.III)(1962:53)

52. Civil War Naval Chronology 1861-1865 (Part IV) (Washington D C, Office of Naval Operations, undated:39)

53. Official Naval Records, "The Union & Confederate Navies in the War of the Rebellion" (Series I, Vol.15) (Washington D.C., Government Printing Office, 1902:13)

54. G. Elliot, "Her Construction & Service" (Part I) of "The Career of the Confederate Ram Albemarle", The Century Magazine (Vol.36[3], July 1888:426)

55. Jones, The Civil War At Sea (Vol.III) (1962:194); & Coggins, Arms & Equipment (1962:149-150)

experimentation in the North and the South, paved the way for not just the legacy of "success" left by the CSS H.L. Hunley, but for a revision of naval strategic planning.

The success of the submarine served to confirm that navies could no longer command the coastal and inland rivers with the naval technology commonly deployed prior to the Civil War. Innovations could counter superior forces. Southern defenders came to consider the submarine and torpedo technology as a "legitimate mode of defence" that formed the most powerful "accessory to our limited means".(56) The torpedo especially became the centre for attempts by both sides to devise ingenious new naval weapons.(See Appendix 10 & 13)

As torpedo technology became more refined and more reliable, it was able to be better deployed. By 1865 torpedoes had been successfully used submerged or semi-submerged in water, buried on land as anti-personnel devices, and used as time bombs on land and at sea.

Throughout the war, torpedoes were responsible for engendering much wider technical changes. Torpedoes may not have been refined into a totally reliable and efficient "modern" sea mine, but experimentation overcame many early shortcomings.

To successfully pursue naval operations the North had to devise their own innovations to counter the deployment of torpedoes. Important innovations were made with fast light patrol-boats with rapid firing guns, intended primarily as fleet defences against torpedo-boats. Effective mine dredges and mine ploughs were devised to clear paths through submarine batteries (or mine fields in modern terminology).(57) On the vessels, iron hulls and thicker hull-side armour were introduced to protect ironclads from torpedo boat attack and from those deployed in the waterways. Other successful Northern attempts to counter night attack by torpedo weapons included electric lamps based on locomotive headlights, star shells, and rocket flares.

Overall, the success of torpedoes during the war reflects the ability of innovators to design a weapon that had immediate uses.(58) In an haphazard manner they then upgraded and changed the weapon to suit new or necessary contingencies.

As innovations improved the utility of existing technology, they served to confirm existing strategic operations. The development of shallow-draft Monitor class vessels

56. Official Naval Records (Series I, Vol.26) (1914:190)

57. For examples of these mine clearance devices See IBID:552-553; & Official Naval Records (Series I, Vol.15) (1902:14)

58. See Perry, Infernal Machines (1985:28-29)

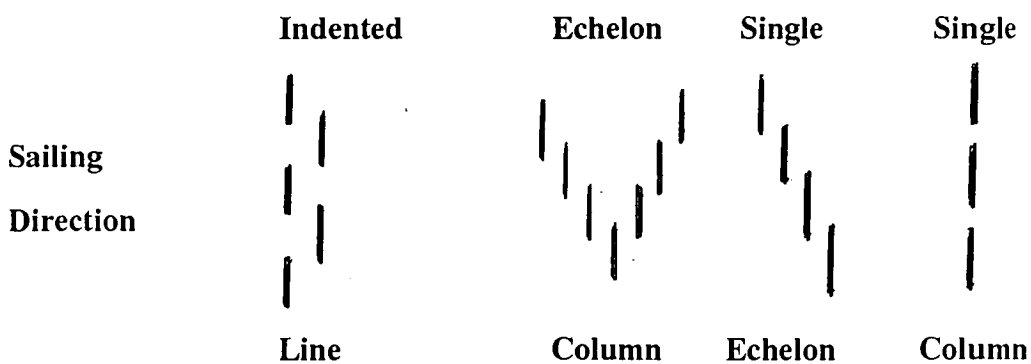
by the North and submarine torpedoes by the South, represent attempts to satisfy opposing strategic imperatives through different innovations.(59)

The limitations on key innovations reflect the lack of importance strategic planners put on certain technical developments. If ironclads had been more seaworthy, both sides would have been faced with new strategic considerations. For the North, this possibility was neglected in favour of maintaining the existing numerical superiority of the blockading fleet, and producing more ironclads that could combat the threat posed by Confederate ironclads. For the South, there was little likelihood of development, given time constraints on design and the Confederacy's depleted resources. While iron-plated vessels added a backbone to steam-driven line warships on the open sea, purpose-built ironclads remained primarily for shallow water deployment.

Strategy was affected much less than battlefield tactics by the introduction of new technical developments. The importance of concentrating a fleet's firepower, whilst also enabling rams to be deployed, was realised by the Union navy. This created new naval formations. Defence in depth, massed firepower, mutual close support, and the avoidance of dangerously close manoeuvring saw formations go from the double indented line to experiments with double- and single-echelon lines. Finally, the single column was adopted. (See Appendix 25)

The first great advantage of using single column naval formations was illustrated by tactics adopted by Admiral Farragut. He deployed ironclad vessels, supported by broadside vessels of the line, to attack coastal forts that defended East coast Confederate ports. This naval tactic was shown to offer strong mutual support and reduce the risk of obstacles in shallow waters and was to be used in the US Navy for many years to come. In fact, it was used when ironclads were added to the high-seas fleet after 1880.(60)

Figure 4



59. McBride, *Civil War Ironclads* (1962:12)

60. Potter & Nimitz, *Sea Power* (1960:242)

The relationship between naval tactics and technology is one of reciprocity. As tactics changed to meet new circumstances technology evolved to fill new needs. Alternatively, as technical refinements and innovations were devised, ways of countering the opponent were often created.

As tactics were refined and operations were successfully undertaken, strategy was consolidated. The North was able to employ its technological advances to assist with the blockade of the Confederacy, bombardment of coastal installations and those close to inland waterways, carry out amphibious operations, patrol and secure inland rivers, provide and maintain army communications, and capture forts and cities.(61) In response, the ingenuity of Confederate innovators, with their limited resources, enhanced the South's strategy of resisting the North's attempts to attain its strategic aims.

On reflection, one can see that the achievements in the North's and the South's efforts to develop naval technology marked a new epoch in nineteenth century warfare. Measured by the overall impact naval technical changes made on the conduct of the Civil War, it must stand as one of the most persistent success stories of naval innovation to come from the preceding two centuries of naval conflict.

8.3 Amphibious Operations and the Impact of Technological Change on Strategy

As military technology and the materials available to wage war changed, military operations during the Civil War did not necessarily automatically alter. The impact of new technology on combat operations has been delineated in two key areas. These are the entrenchment of men on the battlefield, and amphibious operations.

The hasty construction of field entrenchments and earthworks by Civil War soldiers has stood as one of the most important lessons for later wars.(62) The war is studied as an important phase in the evolution of entrenchment on the battlefield. In effect, the increasing use of rifled arms by the end of 1862, had influenced the infantry soldier to place himself in a dug out pit whenever he paused on the battlefield. The longer he stayed in position the greater depth, inter-linking of individual pits, and sophistication these earthworks attained.(63)

The evolution of trench warfare became more consolidated after the actions of individual soldiers was augmented by the Corps of Engineer's skills, when deliberate entrenchment was conducted on a large scale. As the war of manoeuvre settled into a

61. IBID:327

62. Mahon, "Civil War Infantry Assault Tactics"(1961:66)

63. Hagerman, The American Civil War (1988:236)

war of exhaustion,(64) the use of defensive field works by the Confederate forces, and in turn by the Union forces, became a necessary military skill.

General W T Sherman attributed to the terrain and "intrenchments", the cause of high losses in his attacking forces in 1865.(65) Modern authors have also perceived the wartime evolution in trench warfare as the single most important reason for the war being a harbinger of modern warfare.(66) Trench warfare has also been held to represent the end to the war of manoeuvre and the introduction of a period of strategic manoeuvre or defensive positioning from 1864.(67) The responding changes to strategies also instilled tactical and institutional revisions that were to cause a post-war re-evaluation of military practices.(68)

However, only an uncertain emphasis may be placed on the impact of entrenchments as a significant wartime innovation. The maintenance of the war of attrition can be seen as an important period in the evolution of warfare only if it is acknowledged that the generals were unable to use available military force to break the deadlock. In effect the strategy of the day supported defence, with the offensive technologies of the day only overcoming defensive positions with difficulty.

In the case of amphibious operations a much greater emphasis can be placed on the use of new technology to support the breaking of the defensive strategies by supporting innovative offensive tactics. As an offensive operation conducted by the Union forces against the defensive Confederate coastal forts or river strongholds, amphibious warfare is the epitome of how technological changes impacted on the traditional conduct of military operations.

The stress placed on land operations by the Union commanders influenced the performance of amphibious assaults and the allocation of sufficient resources to combined operations.(69) The concentration on the study of the history of land warfare has also biased modern historians' assessments of how technological changes impacted upon Civil War combat.

64. A. Jones, Jomini & the Strategy of the American Civil War, A Reinterpretation", Military Affairs (Vol.34[4], December 1970:127)

65. "The Grand Strategy of the Last Year of The War", in Battles & Leaders of the Civil War (Vol.4) (New Jersey, Castle, reprint 1980:248)

66. E. Hagerman, "From Jomini to Denis Hart Mahan: The Evolution to Trench Warfare & the American Civil War", Civil War History (Vol.13, September 1967:219-210); & Hagerman, The American Civil War (1988:253 & 293)

67. Hagerman, The American Civil War (1988:253)

68. IBID:230

69. This was especially so with the allocation of men and supporting land campaigns. See Beringer (et al), Why the South Lost (1986:189)

Rowena Reed wrote in 1978 that:

The planning of combined movements, their relation to Federal war aims, the effect of technological change on their design and execution, and the multiplicity of economic and political factors influencing the use of combined operations have not been previously examined. Nor has the development of combined tactics received enough attention.(70)

Contemporaries of the Civil War did not overlook many of the lessons that could be derived from amphibious assaults on Confederate defensive positions. Viscount Wolseley noted that the assault on Charleston proved points that could only be tested under the combat conditions existing during the war.(71)

From the end of 1862 the Confederate forces had no real capacity to defeat the Union blockade. But in their efforts to defend themselves against river and coastal assault they produced a fundamental consolidation of defensive technical knowledge.(72) In the construction of defensive forts the South united many technical advances.

While recognizing the wartime importance of the most "complete blockade" in history,(73) Rear Admiral D D Porter (USN) still acknowledged the advances already made by the Confederacy in their capacity to construct defensive forts. Despite the lack of time and resources, the construction of low profile "dirt and sand bag" forts with rifled "foreign guns" provided what Porter believed was an even more formidable defence than the "old-fashioned" masonry constructions.(74) Coupled with the use of obstructions in the form of submarine batteries (mine fields), submerged obstacles, land mine fields and entanglements, attacking forces could not close to bring armed force to bear on the fortifications.(75) When placed together, the new form of defensive works were more formidable than had previously existed. The ability of offensive forces to meet the challenge posed by these supporting defensive technologies represents an important phase in the wartime deployment of new technologies to support strategic imperatives.

The attack on Charleston had held low priority for Rear Admiral J A B Dahlgren because of its seemingly impregnable defences.(76) Yet amphibious operations were

70. R. Reed, Combined Operations in the Civil War (Annapolis, Naval Institute Press, 1978:ix)

71. "An English View", (Vol.149, July 1889:594)

72. W.N. Still, Iron Afloat (Nashville, Vanderbilt, 1971:229)

73. D.D. Porter, The Naval History of the Civil War (New York, Castle, reprint 1984:830)

74. IBID:768

75. Q.A. Gillmore (USArmy), "The Army Before Charleston in 1863", in Battles & Leaders (1980:71-72)

76. Beringer (et al), Why the South Lost (1986:193-194); General G.T. Beauregard, "The Defence of Charleston" in Battles & Leaders (1980:1-23); & for a profile of the Charleston defences see Porter, Naval History (1984:766)

still considered as the most important means of threatening the inland railroads and communication links, and challenging the heart-land of the Eastern war theatre.(77) By mid-1864 it was obvious that the capture of Charleston and the more impregnable harbour defences were necessary if the strategy of blockade and the naval support of land operations was to be achieved.

In 1863 limited progress had been made towards defeating the Charleston harbour defences. The slow firing, but well protected Monitor craft, were backed by faster firing broadside ships to effect the total destruction of Fort Sumter.(78) By January 1865, strategy for the assault of Confederate forts had evolved to a point where the seemingly impregnable Confederate Fort Fisher, fell to the combined efforts of a naval force headed by ironclads, and land forces lead by General Butler.(79)

The North succeeded in this latter attack only because the commander, Admiral Porter, had learnt how to integrate ironclads into his fleet, and realized the importance of joint preparatory planning between naval and ground troops. The success at Fort Fisher highlighted how the Union forces could also plan, conduct, support, and aid troops in combined operations. Against an enemy force intent on defending the last remaining major port still open, the naval and land forces were still able to be victorious.

The impact ironclads could produce on fortifications was central to the successful attack on Fort Fisher. Earlier in the war combat experiments had been conducted to assess the use of different ammunition against Confederate forts.(80) A combination of hollow explosive ammunition, explosive projectiles, and solid shot against forts had been shown to be most effective.

The bringing to bear of sufficient naval force was not necessarily a lesson that would be easily learnt by Union commanders. With a total weight of metal at 14268 pounds and a combined broadside weight of 9288 pounds, in his attack on Mobile Bay Admiral Farragut felt convinced he had an attacking fleet of unparalleled might.(81) Nevertheless, a torpedo claimed the ironclad Tecumseh and more sailors than assault troops died in the subsequent attack on Fort Gains.(82)

77. Beringer (et al), Why the South Lost (1986:199); & H. Hattaway & A. Jones, How the North Won (Urbana, University of Illinois Press, 1983:142-143)

78. Allard, "Naval Technology", (1989:116)

79. For a description of Butler's "gun boat army" see H.C. Westwood, "Benjamin Butler's Naval Brigade", Civil War History (Vol.34, September 1988:270)

80. See the experiments against Fort Hindman in January 1863) Battles & Leaders (1980:290-292)

81. Parker, Battle of Mobile Bay (1878:21)

82. IBID:77 & 119

Doubts as to the ironclads' ability to be deployed effectively against shore batteries (83) were overcome as innovations and techniques improved the technologies general efficiency of existing technology. In an evolution of strategy, supported by new technologies, combined operations were improved. As an unconscious response to Confederate defences the North had to develop ways to meet their strategic goals. For the Confederate forces, the initial spur to defend their coast and rivers promoted the innovative use of available technical knowledge.

Innovations in technology and technique permitted amphibious operations to succeed in meeting the corresponding changes being devised by the defensive forces. With the support of technological changes, combined operations consolidated a new strategic dimension in contemporary military annals. The establishing of these lessons under Civil War combat conditions, therefore, increased further the value of these lessons for future wars.

CHAPTER 9: THE IMPACT OF CIVIL WAR TECHNOLOGICAL CHANGE ON THE WORLD ARENA

For contemporary nations, the immediate consequences of Civil War military technological change were less than profound. While European armies disregarded certain combat tactics as unique to the war, they consistently failed to appreciate the success of those innovations involved.

In spite of an initial reluctance to acknowledge the importance of American innovations, some technologies were nonetheless to exert a significant influence on the conduct of warfare. While few perceived the Civil War as having any special characteristics, some foreign military observers still managed to identify important changes that were affecting the conduct of warfare. Observers such as the Frenchman Vigo Roussillon, noted that the "great strides in weapons, military transport, signals and engineering devices" held a positive interest for European armies.(1) The Russian Ambassador to Washington, Baron de Stoeckl, wrote that the battle at Hampton Roads:

marks an epoch in naval history...shows beyond a reasonable doubt the superiority of armour-plated ships over wooden ones.(2)

Such insights could not be passed over as unique observations from men with great vision or some fortuitous predictions made by chance. Such penetrating observations were repeatedly made by many observers of the Civil War conflict.(3)

How then was it that no clear message of the Civil War's importance, particularly as an indicator of the power of modern technological developments, was conveyed directly to the major world powers?

Having studied the technological innovations of the Civil War and examined their impact on arms and battlefield strategies, we must now consider their impact on the armies and navies of other nations.

1. J. Luvaas, The Military Legacy of the Civil War (Chicago, University of Chicago Press, 1959:145)

2. B.B. Sideman (ed), Europe Looks at the Civil War (New York, Onion Press, 1960:193)

3. N. Malcolm (ed), The Science of War: A Collection of Essays & Lectures, 1891-1903: By the late Colonel G.F.R. Henderson (London, Longmans, Green & Co., 1910:Chapter 6)

Henderson was a great student of the Civil War and the impact it made on Continental strategists

9.1 The Legacy of Military Technological Change

Two lessons should be immediately apparent from the technical advances than occurred during the American Civil War. Firstly, the North's massive industrial base permitted it to design and produce weapons that gave it an unchallenged strategic advantage over the South. The second lesson may, however, seem to contradict this, for the South's ability to conduct its own defence was also greatly enhanced by the successful deployment of some crude, but nonetheless ingenious, weapons. Taken together, these two lessons illustrate that technical changes were not only becoming a vital process in the conduct of war, but that the resultant technological developments were affecting the means of conducting armed conflict.

Contemporary students of the Civil War never fully appreciated the process of technological change. When we look at their acceptance of how technical innovations could affect warfare, we get a mixed response. Differences lay in the perception of how industrialization could alter not only the means of producing weapons but the range of weapons available to those participating in martial conflict. For Europeans the methods of conducting war had been established in the writings of Napoleon, Wellington, Frederick the Great, Jomini, and Clausewitz.(4) Consequentially, these writings dictated the type of weapons deployed in European campaigns.

While the American Civil War emerged as the testing ground of new technology and highlighted a new approach to warfare, for the European military leaders, it was generally viewed as just adding a new dimension to existing strategies. It was not widely regarded as a divergence from accepted past military strategies.

As has been already found, the use of rail represents an important lesson enforced by Civil War experiences. The precedents, problems, and potential for railroads were established in the war and set the example "the rest of the world had simply to follow, adapt or perfect."(5) It was immediately apparent that rail increased mobility by reducing the size of supply columns.(6) Europeans realised that this would enable them to range over greater distances, go further from their supply depots, and, given the size of Western Europe, rapidly deploy and support soldiers from a home base.

4. R.A. Leonard, A Short Guide to Clausewitz On War (London Weidenfeld & Nicolson, 1967:25)

5. E.A. Pratt, The Rise of Rail-Power: In War & Conquest, 1833-1914 (London, King & Son, 1915:ix)

6. M. Howard, The Franco-Prussian War: The German Invasion of France 1870-71 (London, Rupert-Davis, 1962:3)

The lessons contained in the Civil War, however, should not be overstated. Rail had been used as a military tool in Europe prior to 1861.(7) The strategic significance of rail was acknowledged by the Prussians when during 1864, they established a railways section in their General Staff. In 1866, the Field Railway Section (which was modelled on the US Construction Corps) was added to the Prussian army.(8) In practice the railway played a vital strategic role in the Prussian wars against the Austrians during 1866, and then against the French in 1870.

The use of ironclads in the Civil War also represents an example of how the value of technical knowledge could be confirmed, then through subsequent use have its military utility enhanced by technical refinements. Ironclad vessels had been launched by the English and French from 1859 onwards. Throughout the Civil War both these nations participated in a race to build more and better ironclad warships. But American purpose-built ironclads with turret mounted cannon and steam propulsion, produced weapon systems that offered new potential to European nations. The proof of ironclads' superiority over wooden vessels and the speed with which the United States built such a formidable fleet, accelerated the pace of other world navies' development of ironclad technology.

The lessons learnt from the deployment of ironclad technology were, however, not always clear. Hampton Roads in particular showed the power of an ironclad ram against wooden vessels. The conflict between the Monitor and Virginia was much less decisive. In this conflict no significant lessons were learnt about how to improve ironclad vessels offensive capabilities. This was the case throughout the war, with no significant indications being made on how to decisively improve the architecture of the vessels, or to promote the use of different artillery types.(9)

The means of countering ironclads in coastal or river systems were also quickly appreciated. As ironclads were developed the ancillary need to possess torpedoes, torpedo-boats, patrol-boats, and boats capable of deploying rapid firing weapons, to destroy small attacking vessels was also realised.

By 1870 torpedoes, torpedo-boats, monitors, and sea-going ironclads could be found in Sweden, France, Britain, Spain, the Russian western and far eastern navies, Chile, Peru,

7. During the Franco-Austrian War of 1859, between 19 April till 15 July, the French moved 604,000 men and 129,000 horses, from Paris – Culoy – Marseilles – Toulon – Grenoble to Aix. See Pratt, The Rise of Rail-Power (1915:9–10)

8. J. Luvaas, The Education of an Army: British Military Thought, 1815–1940 (Chicago, University of Chicago Press, 1970:145); & L.C.F. Turner, "The Grand Strategy of the Civil War", Australian Journal of Politics & History (Vol.26[1] 1980:67)

9. J.P. Baxter, The Introduction of the Ironclad Warship (Cambridge, Harvard University Press, 1933:285); & D.C. Allard, "Naval Technology During the American Civil War", American Neptune (Vol.49, Spring 1989:115 & 119)

and elsewhere.(10) Despite this, the lessons of the Civil War were quickly suppressed. From 1866 till 1874 the US Congress failed to sanction any new naval construction.(11) The reduced emphasis on naval forces in the rest of the world also meant failure to expand on the new naval technology started by the Civil War.(12) Although Britain, France, and some other European nations undertook to armour warships and experiment with new cannons, important design innovations progressed slowly.

Many weaknesses of early ironclads were not to be overcome until the 1880s. The use of muzzle-loading rifled cannons, the lack of open-sea stability due to the low Monitor style freeboards, and poor engine designs remained.(13) Many Monitor designs, as laid out by John Ericsson and later improved by Ericsson and other designers, were to remain in naval front-line service till after the First World War.(14) Other naval designs such as torpedo-boats and patrol-boats were refined as cheap alternatives to building larger vessels. The submarine, however, had to wait until the 1880s and 1890s before its design included modern propulsion systems and satisfactory underwater capabilities.(15)

Naval technology had an impact on the world's navies, confirming basic developments already experimented with by some nations. However, the stagnation in naval development for almost two decades after the Civil War brought to a standstill the development of innovations made in the war.(16)

Like the development of the ironclads and the railway, the telegraph had its potential more fully exploited after the Civil War. The electric telegraph and its mobile field model added a new strategic dimension to the use of large armies. It added new potential for the command and control of large armies over widely spread fronts. Coupled with rail, the telegraph became an accepted tool necessary for American commanders to efficiently co-ordinate troops.

The telegraph's use in the Civil War served to confirm how it could be used on a large scale. The fact that European nations already had the rudimentary technology, but

10. Purnells Illustrated Encyclopedia of Modern Weapons & Warfare (Vol.I) (London, Purnells, 1976:109–110); & (Vol.V) (1976:1448)

11. IBID:109

12. W. Millis, Armies & Men: A Study in American Military History (London, Jonathan Cape, 1958:132)

13. C. Dixon, Ships of the Victorian Navy (Southampton, Ashford Press, 1987)

14. Purnells Illustrated Encyclopedia (Vol.V) (1976:1448–1449)

15. In 1881 a Spaniard J Peral launched a successful battery powered submarine. Development advanced as diesel engines were developed & replaced steam, battery and petroleum propulsion designs. By 1904 Germany launched the U1 built at Kiel. This can rightfully claim to be the first successful production submarine model.

16. S. Sandler, "A Navy in Decay: Some Strategic Technological Results of Disarmament 1865–1869 in the U.S. Navy", Military Affairs (Vol.35, December 1971:138)

used the electric telegraph as a more developed military tool only after 1862, can be credited to the American Civil War. The war showed how innovations had expanded its battlefield utility and made it a more effective controller of front-line operations.

In small arms technology, it is less easy to identify the extent to which Civil War innovations affected other nations. Developments occurred across such diverse areas and with such a varying degrees of success, that their importance to other nations is difficult to estimate.

By 1866 most European armies were experimenting with alternatives to rifled muskets. Since the early 1850s, Prussia had experimented with the Dreyse needle gun which was the forerunner of the bolt-action rifle. By 1862 the design was refined to a 0.47 calibre needle gun that was to equip all Prussian infantrymen.⁽¹⁷⁾ By 1866 the French had also introduced a 0.434 calibre Chassepot bolt-action rifle.⁽¹⁸⁾ (See Appendix 23) Austrians were also introducing the bolt-action Snider Rifle by the mid-1860s. All these rifle designs were converted or designed to take centre-fire metallic cartridges. However, in 1863 none of the designs could match the efficiency or firepower of the American Sharps or Spencer rifles. Nor had the designs overcome the problem of machining a breech assembly that would prevent gas leakage. This was compounded by their better quality nitre which produced greater pressure on firing.

By the end of the American Civil War, Britain still relied on the 1853 Enfield percussion rifle as its major infantry weapon. It was essentially the US Springfield, made from machinery and mills imported from America in the mid-1850s. By 1870 Britain adopted the breech-loading, rimfire, single-shot rifle based on the same design. This was in fact a copy of the system the Americans had adopted, when in 1868, they converted their Springfield rifles to fire rimfire metallic cartridges.⁽¹⁹⁾ Britain, like America, stayed with a reliable, conservatively modified rifle, that cost little to convert from existing rifled musket stocks.

As with the ironclads, the small-arms technological changes were not developed after the Civil War. However, isolated examples of continued innovation did occur. In the area of rim-fire and centre-fire metallic cartridges, the Civil War established their superiority, and rifles, revolvers, and machine-gun designs were refined to better use these ammunition developments. European cavalry still spurned the use of breech-loaders and revolvers, for the sabre and lance. While machine-guns were still being deployed as artillery pieces. Despite such limitations, American technological innovations in all these areas still influenced European armies.

17. F. Wilkinson, *The World's Great Guns* (London, Hamlyn, 1977:89)

18. IBID:101

19. D.F. Butler, *United States Firearms* (New York, Winchester Press, 1971:179-184)

Technology transfer from America to the world was quickly achieved through individual innovators relocating in Europe. Just as Ericsson was to take the Monitor design to Sweden and South America,(20) so Benjamin Hotchkiss took his knowledge and innovations to France. Here he became responsible for establishing a whole new generation of weapons innovations. Colt, Smith & Wesson, and Winchester firearms companies, extended their weapons designs and foreign sales to the European arms market.

As the post-war American market was saturated with wartime weapons, the numerous wartime arms manufacturers had to look overseas to find new markets. As arms were sold in Europe, so the means to produce these arms were relocated to the market centres. Prior to 1861, only Great Britain had imported American small-arms machine-tools and milling techniques. By 1870, however, Belgium, Spain, Turkey, Denmark, and Egypt had followed suit.(21)

Regardless of the advantage in firepower or design that the American rifles and pistols held, European nations ignored them when re-arming their infantry. Through the Europeans' nationalistic honour or through their failure to appreciate their tactical role, American weapons did not gain wide adoption in the leading European armies. Design features were used, or innovators from America were employed, but the weapons themselves remained largely overlooked.

Of all the small arms to create an impact on the international arena, the machine-gun stands out. The Gatling gun's greatest impact was to occur outside the confines of the Civil War. The success of the Gatling was dependent on post-war improvements in its rate of fire, metallic ammunition, alternative calibre sizes, and later the perfection of its cooling and magazine feed.(22) It was adopted widely by such nations as Great Britain, Russia, France, and Turkey. It was to be used extensively on land and at sea.

In comparison to the French Mitrailleuse, the Gatling was more reliable and quickly able to enforce its tactical role as a defensive weapon. The success of Russian Gatling Guns used against the Turks, and the success of the British weapons when used in their colonial wars, laid the foundation for further machine-gun design work. Designs such as the Gardiner, Nordenfeldt, and Maxim guns, evolved rapidly. These designs in turn created a degree of mechanical efficiency in machine-guns that was to provide perhaps the single greatest impact on land conflict after the turn of the century.(23)

20. Purnells Illustrated Encyclopedia (Vol.V)(1976:1317)

21. W.H. McNeill, The Pursuit of Power (Oxford, Basil Blackwell, 1983:235)

22. D.A. Armstrong, Bullets & Bureaucrats (Westport, Greenwood Press, 1982:36-37)

23. I.V. Hogg & J. Batchelor, The Machine-Gun, (London, Phoebus, 1976:6-14); & W.R. Hamilton, "American Machine Cannon & Dynamite Guns", The Century Magazine (Vol.36[6], October 1888:885-893)

A number of other Civil War military technological innovations were to affect the armies and navies of the world. In 1864 Britain sent a commission to investigate a number of areas that interested the British War Lords.⁽²⁴⁾ The final Gallway and Alderson Report of 1864 listed a number of innovations, that were a strong indication of the technologies that were to affect other nations' contemporary military development.

The key areas of examination included: (a) the system of rifling used; (b) breech-loading and polygonal oval boring; (c) lead-coated projectiles; (d) composition of field batteries; (e) rifled guns available to fire round shot; (f) how to strengthen cast guns; (g) the operation of balloons; (h) the value of explosive bullets or "small arm rifle shells"; (i) the use of steam traction for military transport; (j) success of union repeating guns or other multi-barrelled rifled weapons used in the field; (k) the problem of confusion on calibres and the damage done to supply; (l) the merit of small arms used and contrived (range, accuracy, rate of fire, and so on).⁽²⁵⁾

It is worthy of note that the British War Lords were interested in the impact technologies had on the war. The Report represents the extent to which the British, at least, used the Civil War as a reference point in their assessment of how military innovations were able to perform.

The pool of technical knowledge created by experiments with grenades, defensive positions, weapon sights, hollow artillery shells carrying chemical mixtures, flare guns, trench mortars, sea mortars, rail guns, new explosive ordnance, and so on, all contributed to industrialised nations' ability to further build new military innovations.

Unfortunately, much Civil War technical innovation was lost, either because it could not establish its vital tactical role or because post-war stagnation in arms development stifled interest. The US model Sharps and Spencer rifles, for instance, were more effective weapons than the Dreyse. The Dreyse had a weak firing-pin, inferior ammunition, and a bolt configuration that did not completely stop gases from escaping. Nevertheless, it was still considered a marvellous weapon when it devastated Austrian massed line-in-depth formations in 1866.⁽²⁶⁾ In the Russian-Turkish War, the use of Winchesters, Gatling guns, and land mines harkened back to the Civil War. With the war's removal from Europe, the reliance on siege warfare, and the pre-occupation of Europeans with Prussia's military presence, the impact of such insights were much reduced.

24. Luvaas, *The Military Legacy* (1959:35-36)

25. IBID

26. McNeill, *The Pursuit of Power* (1983:245)

The impact of Civil War military technological development may be linked to a number of important influences. Seemingly the European nations were all too willing to accept the lessons of the war in a haphazard fashion. Existing military needs determined the rate of technical development. Unfortunately, priorities were established by weighing the economic cost of innovations against immediate military threats. Thus, naval technology was accepted quickly but evolved slowly.(27) Land warfare innovations were accepted slowly and developed, for the most part, only spasmodically.

Safe technology that built upon known technical developments or could be introduced without disrupting the configuration of existing military institutions was most likely to find early acceptance. But innovations and the new pool of knowledge created by recently deployed or designed Civil War weapons, apparently influenced future international military technical knowledge.

9.2 The Civil War as a Testing Ground for Subsequent Wars

Liddell-Hart wrote:

... when the analyst passed from the American Civil War to the Wars in Europe which followed on its heels he is likely to be impressed above all by the sharpness of its contrasts.[sic](28)

In Europe, battles were again to be conducted on open meadows with disciplined soldiers, artillery in close-fire support, and cavalry with sabres and lances. They fought to secure the offensive initiative.

Did, then, any of the Civil War's innovations contribute to subsequent wars?

To European military experts the strategic lessons of the Civil War had little importance. They saw the American war as a battle between semi-regular forces of the North and virtual guerilla forces of the South.(29) For Helmuth Von Moltke, the Chief of the Prussian General Staff, studying the "movements of armed mobs"(30) was dismissed as uninformative. Moltke's views reflected the general opinion held in the world's leading armies, that the American forces were not only unprofessional but were also led by part-time generals who constantly made flagrant mistakes and tactical

27. Allard, "Naval Technology" (1989:122)

28. B.H. Liddell-Hart, Strategy: The Indirect Approach (London, Faber & Faber, 1967:154)

29. Liddell-Hart, Strategy (1967:142)

30. M. Earle (ed), Makers of Modern Strategy (Princeton, Princeton University Press, 1973:166)

miscalculations.(31) The men they led were seen as undisciplined, poorly dressed, lacking in co-ordination when in attack, and too eager to take cover when under fire.(32)

European armies could not accept the abandonment of traditional line and column tactics. They were too ready to blame poor leadership, lack of discipline, and the American terrain for these tactical anomalies. The success of General Lee's Napoleonic-style battles of 1861 and early 1862 was viewed with more interest.(33) The strategy of attrition and attempts at Southern annihilation by General Grant and General Sherman in 1864 and 1865 were seen as avoiding brief Napoleonic-style climactic battles. This defied the Continental tactics of Jomini, Clausewitz, and others, in which troops should be concentrated in a swift strike against an enemy's weakest point.(34)

Equally incomprehensible to European analysts of the Civil War was the relegation of cavalry to mobile infantry. Cavalrymen were deployed as guerilla units or in skirmish lines in front of armies, but were not used as shock troops.(35) The concept of using mounted troops solely for interdiction and reconnaissance was not to be found in European books on tactics. It was not until 1870 at Rezonville, Sedan, when the Chasseurs d'Afrique were destroyed by Prussian small-arms and artillery fire, that Civil War lessons on the futility of using cavalry to attack prepared troops armed with modern weapons were rediscovered.(36)

Although the Civil War had confirmed the argument of Clausewitz that defence was the stronger form of war,(37) Europeans often overlooked this singularly important strategic lesson. More astounding was the ability of contemporary armies to ignore even the most significant tactical lessons that resulted from technological changes. This ignorance of the war's true strategic legacy is forwarded by many modern authors as

31. IBID:166; & Comte Charles De Montalembert in Sideman, Europe Looks at the Civil War (1960:286)

32. J.F.C. Fuller, The Decisive Battles of the Western Worlds (Vol.III) "From the American Civil War to the End of the Second World War" (London, Eyre & Spottiswoode, 1956:36); & Luvaas, The Military Legacy (1959:3-4)

33. For a complete discussion of General Lee and General "Stonewall" Jackson's use of Napoleonic style strategy see R.F. Weigley, The American Way of War: A History of United States Military Strategy & Policy (New York, MacMillan, 1973:Ch. 6)

34. IBID:95 & Ch. 7

35. M. Howard, The Theory and Practice of War (London, Cassell, 1965:82); R.S. Brownlee, Gray Ghosts of the Confederacy (Baton Rouge, Louisiana State University Press, 1963:4); Fuller, The Decisive Battles (Vol.III) (1956:36); & Luvaas, The Military Legacy (1959:5)

36. D.G. Chandler, Atlas of Military Strategy: The Art, Theory & Practice of War, 1618-1878 (London, Arms & Armour, 1980:165)

37. Chandler, Atlas of Military Strategy (1980:131)

the greatest reason why the war never has attained a clear place in the evolution to modern warfare.(38)

Many important nineteenth century tactical developments became features of the Civil War. The use of cover and movement in attack was necessary due to the longer range and greater accuracy of small arms and artillery. Also, small-arms developments allowed men to load and fire from the prone position.(39) Cavalry armed with breech-loading rifles and revolvers were a far more flexible tactical tool, with improved offensive and defensive uses. The improvements in the accuracy and range of artillery permitted not only more effective fire support for troops but also precipitated improvements in defensive positions.(40) As engineering of entrenched defensive positions improved, a shadow was forever cast over the fast mobile shock tactics common to mid-nineteenth century Europe. Increasingly, it was the commanders capacity to supply and keep a massed army in the field, that became the decisive indicator of the types of strategy employed.(41) General Longstreet wrote at the end of the Civil War that the:

...time had come when it was imperative that the staff of generals and the strategy and tactics of war should take the place of muscle against muscle.(42)

He reflected the vision that European Generals felt had remained unchanged. Longstreet desired a return to an "art of war" that had been forgotten, not the strategy of exhaustion, that dominated Civil War generalship.(43)

The European armies' tactics, and particularly the Prussians' offensive strategy,(44) were concentrated under offensive tactics that preserved not only the army's integrity of purpose but also its fluidity of movement. Assessed on this basis, the American tactics were negative and strategic objectives were not effectively consolidated.

38. E. Hagerman, The American Civil War & the Origins of Modern Warfare (Bloomington, Indiana University Press, 1988:xvii); A. Jones, "Jomini & the Strategy of the American Civil War, A Reinterpretation", Military Affairs (Vol.34, December 1970:129); & R.E. Beringer, H. Hattaway, A. Jones, & W.N. Still, Why the South lost the Civil War (Athens, University of Georgia Press, 1986:16-20)

39. Luvaas, The Military Legacy (1959:27)

40. E. Hagerman, "From Jomini to Denis Hart Mahan: The Evolution to Trench Warfare & the American Civil War", Civil War History (Vol.13, September 1967:197-220)

41. For an up to date assessment of the relationship between supply and manoeuvre see E. Hagerman, "Field Transportation & Strategic Mobility in the Union Armies", Civil War History (Vol.34, June 1988:143-171)

42. Wolseley (Viscount), "An English View of the Civil War", North American Review (Part IV) (Vol.149[394], September 1889:281)

43. Jones, "Jomini & Strategy" (1970:130)

44. Liddell-Hart, Strategy (1967:143)

The major European powers were not prepared to concede that American battlefield tactics of open-order swarms or flexible linear battalion or company formations were acceptable. The British from Wellington until Lord Kitchener in 1880 maintained two-deep linear formations.(45) The French did not change until the 1870s when the Chassepot rifle was widely used, and their defeat at Sedan forced changes to attacking in columns. The Prussian, Von Moltke, although a visionary, still directed massed troops at decisive points. His tactical system was reliant on the sub-unit formation patterned on Napoleonic principles.(46) Not until the Chassepot devastated Prussian ranks – in 1870 at St. Privat, the Prussian Guards Corps lost 8,000 in 20 minutes – did experimentation with new formations occur.

Strategically, the general course of military operations in the North and South was viewed by other nations against a backdrop of "enormous tactical blunders." (47) These blunders often occurred because technical developments had altered tactical situations. Generals of both sides often failed to realise how new technology had altered battlefield tactics.(48) Innovations also provided a two-edged sword to commanders. Rail offered new mobility, but Civil War commanders tended to cling to rail while advancing, so removing flexibility and bold manoeuvres from campaigns.(49) The telegraph, while improving communications, also provided an unprecedented opportunity for political authorities to interfere in the implementation of strategy.

Without a strong American General Staff Corps or similar organisation (the US War Board of the General Staff from 1861 to 1863 had little real strategic control and was mostly an informal institution),(50) the European armies, with their strong central military organisations, saw both the Northern and Southern strategies as uncoordinated.(51) Control of resource allocation and swift deployment of troops were seen as having no structure. General Meigs, a strong critic of fellow Northern generals, admitted that no single man was "the author of all the plans of campaign finally accepted." (52) The Europeans felt justified in believing they had no lessons to learn from the bodies organizing Civil War strategy.

45. Henderson in Malcolm, The Science of War (1910:339f)

46. Chandler, Atlas of Military Strategy (1980:165)

47. Fuller, The Decisive Battles (Vol.III) (1958:89)

48. IBID

49. Chandler, Atlas of Military Strategy (1980:166)

50. See H. Hattaway & A. Jones, "The War Board, The Basis of the United States First General Staff", Military Affairs (Vol.46[1], February 1982:4)

51. The Board followed the establishment of European War Boards in Austria 1840s, Prussia and France in the 1850s, and Britain's informal Board from 1853.

52. M.C. Meigs, "On the Conduct of the Civil War", American Historical Review (Vol.26[2], January 1921:291)

Reluctance to learn from organisational arrangements in the North still did not limit the lessons observers learnt from the use or misuse of technical innovations.

Captain Justus Scheibert, of the Prussian Army, noted the use of rifled artillery on traditional masonry and earthworks.(53) He wrote of the decline of old defensive structures and noted the power of defence. The power of entrenchments to negate superior numbers and weapons was also examined.(54) The Duke of Cambridge believed that the spade and axe had ushered in a new age of defence. He believed the improvements in small arms and artillery would increasingly make defensive entrenchments a permanent feature of wars.(55) On land "lavish examples of the problems and possibilities which rail transport provided to strategists"(56) were illustrated by the Civil War. Rail as a means of supply, and reinforcement, and as a strategic objective itself, was shown to European observers.

In the air, balloons were watched by many nations with interest. Interest in balloons for military purposes was revived in Britain, France and Prussia. One observer, Graf von Zeppelin, was himself to become famous for his promotion of airship technology.

The influence of small-arms technology on military tactics was recorded by a number of observers, none of whom was more influential in his home country than G F R Henderson. His writings, including such works as, Stonewall Jackson and the American Civil War (1898), the Campaign of Fredericksburg Nov-Dec 1862: A Tactical Study for Officers and numerous essays,(57) were widely read by military cadets in Britain around the turn of the century.(58) Nevertheless, it is difficult to discern any significant impact having been made by Civil War tactical lessons on European military doctrine.(59)

Other observers, such as Viscount Wolseley, noted that tactical changes were caused by technology changes at sea. Wolseley believed it was important to note how the strategy of the Northern navy and army was made in consideration of each other. In fact, he credited combined operations, amphibious landings, increased coastal defence, and the use of ironclads and patrol-boats in inland areas to support land warfare, with having

53. Luvaas, The Military Legacy (1959:60)

54. IBID:73

55. IBID:107

56. M. Howard, War in European History (London, Oxford University Press, 1976:98)

57. See Bibliography

58. Malcolm, The Science of War (1910)

59. Howard, The Theory and Practice of War (1965:82); & Although Henderson's works seems to have influenced British officers trained in the 1890s and commanding troops in the First World War, J. Luvaas, "G.F.R. Henderson & the American Civil War", Military Affairs (Vol.20, Fall 1956:150)

added a new strategic dimension to military strategic journals.(60) At the same time, Wolseley continually confirmed how technical developments reinforced the basic naval strategy of blockade.

Fundamentally, the world's navies observed how Northern superior numbers and technical innovations were able to deny command of the sea to the South. The tactical use of the navy to blockade the South, control rivers, and support army operations, served to provide the conditions where their strategy could succeed.(61)

In naval matters, observers and the writings of contemporary American naval commanders found a more immediate audience. The use of single-column deployment of line warships, adoption of armour and armament to facilitate close-quarter gun duels, and the use of defensive technologies such as torpedoes and their delivery vehicles, were widely noted. However, just as technological innovations inspired similar developments the world over and then stagnated, so tactical developments also stagnated.(62)

Developments had not removed or changed the strategic imperatives of the world's leading maritime nations. Tactics were affected by technical developments that occurred in the Civil War or by later innovations, but few major nations were engaged in wars involving control of the seas. While the technical character of naval wars changed rapidly, its strategic impact was stifled. Not until the 1880s, and more fully in the next century,(63) were the modern weapons of naval warfare able to exert their influence upon a nation's grand strategy.

Essentially, the Civil War provided an influential combat testing ground for modern naval technology. The impact of certain technological changes were established, but advances were limited to the immediate new strategic considerations of the war.(64) For instance little was derived by way of using ironclad vessels in the open seas against enemy forces.

The study of Civil War technology change lent weight to other nations' knowledge of certain tactics. The impact of new technology and aspects of how it could be deployed were observed. At sea, as on land, there does not appear to have been a concerted

60. Wolseley, "An English View", (Vol.149, 1889:597)

61. J.S. Corbett, Some Principles of Maritime Strategy (London, Longmans, Green & Co., 1911:87)

62. For a discussion of the late nineteenth century revival in US Navy strategic thinking see K.L. Moll, "A.T. Mahan, American Historian", Military Affairs (Vol.27, Fall 1963:131)

63. D.D. Porter, "Naval Wars of the Future", North American Review (Vol.148[387], January 1889:196-216)

64. R. McBride, Civil War Ironclads: The Dawn of Naval Armour (New York, Chilton Books, 1962:157)

attempt by any leading nation to adopt Civil War tactics directly. The drawn-out conflict was blamed on the failure of generals to achieve a quick and decisive victory. Technical innovations did not apparently alter this situation; and, therefore, it was thought the contribution of these new technologies should be considered only with regard to their ability to assist existing European strategies.

Many other features of the Civil War were to be translated into action around the world. Technological advances and tactical changes were reinforced in wars such as the Russo-Turkish War of 1877, the Chile-Peru conflict, and British battles against the Zulus, the Ashantees along the Gold Coast, and the Boers in South Africa.

In the Russo-Turkish conflict, for instance, the siege of Constantinople illustrated the power of Turkish defensive tactics. In battle, Turks used repeating Winchesters, Gatling guns, and land mines to hold off Russians who also deployed the Gatling gun (renamed the "General Gorloff"). In the Chile-Peru conflict, the power of ironclads in joint operations and repeating small arms in land conflicts was highlighted. Against the Ashantees, the British took balloons and a telegraph signals section. Against the Zulus, one Gatling gun was able to cut down 473 Zulus in a 500-yard arc when they charged a British defensive position.(65)

Numerous stories exist of how Civil War innovations had affected conflicts around the world. As railroads spread across the globe, their military capabilities became a major consideration. From 1864 to 1876 the Gatling gun was adopted by Russia, Turkey, Tunis, Morocco, Japan, and European nations. Its extensive use, modification, and suitability for use on land or sea, presented enormous firepower to even the most ancient armies.

The Austro-Prussian War of 1866 and the Franco-Prussian War of 1870 have been regarded as more akin than the Civil War to the total wars of the twentieth century. They deployed modern weapons of mass destruction and necessitated a massive commitment of the State to the war. This total war concept has been used to distinguish between the limited wars of more traditional eras. Here limited interests, limited objectives, and the restricted time and geographic space of conflict involved less sustained strategic operations.(66) Although definitions vary in detail, and despite the fact that neither expression is really satisfactorily defined, the Civil War is often not included with the Wars of 1866 and 1870 as forerunners of total wars.

However, there are significant features of the Civil War that indicate it had aspects of total commitment. There was, for example, a commitment of industrial capacity and

65. Hamilton, "American Machine Cannon" (1889:886)

66. Corbett, *Maritime Strategy* (1911:81)

the exploitation of innovations in steam technology, electric telegraph, and weapon systems. None of these factors had uniformly occurred in previous 'limited wars'.

It could be suggested that the European wars of 1866 and 1870 were accepted as more like total wars because the legacy of the Civil War was unrecognized in Europe, and that today's analysts have mostly failed to highlight the war's important differences from limited wars.⁽⁶⁷⁾ The impact of Civil War technology was often limited by European nationalistic views. Interested in an expansion of military forces from their own indigenous industries, major European military powers were mostly pre-occupied with the possibilities of their own technologies.⁽⁶⁸⁾ Designers had to very closely monitor national politics and convince the network of advisers and committees of their particular weapon's merit.⁽⁶⁹⁾

Paradoxically, despite many innovations not being fully utilized in the Civil War, the war produced men with a new outlook on military technical knowledge. Regardless of innovation's impact in America and overseas, technologists were building on the increased body of military technical knowledge to devise new weapons. Indeed, some of the world's most famous military inventors were to build upon Civil War innovations. The American Civil War's legacy was to spur noted American military innovators such as Samuel Colt, Sir Hiram Maxim, Dr Richard Jordan Gatling, William Gardner, Benjamin Berkeley Hotchkiss, Colonel Isaac N Lewis, John Browning, Major Thomas Rodman, John Ericsson, Christian Sharps, Francis D Lee, James P Lee, Erskin Allins, and many others.

Many great companies were built on the legacy of Civil War innovations. Some, like Winchester, Remington, Smith and Wesson, Ruger, Du Pont, and Colt, owe their longevity to the impetus produced by the Civil War. Rail, telegraph, foundry, chemical, and textile companies could also attribute much of their post-war success to specialist work done in their fields during the war.

The combined impact of knowledge, innovators, and corporate sponsorship took American arms into the world market after 1865.⁽⁷⁰⁾ Contradicting this trend the Americans dismantled their military organisation after 1865, and virtually curtailed the

67. An oversight challenge by Edward Hagerman in *The American Civil War* (1988); & Hagerman, "Field Transportation & Strategic Mobility" (1988:167)

68. M. Pearton, *The Knowledgeable State: Diplomacy, War & Technology Since 1930* (London, Burnett Books, 1982:27)

69. IBID:45

70. Howard, *The Franco-Prussian War* (1962:247 & 390)

production of new military technology. To Europe, this reinforced the belief that the lessons of the Civil War were transitory. European military doctrine was left largely unimpressed by the immediate impact of the Civil War.⁽⁷¹⁾ All the war seemed to provide, was a study piece for the use of specific technical innovations in war and a limited insight into interesting tactical formations.

In effect, the war was to provide the basis for future innovations but its significance as the first industrialised war or total war, can be argued only in retrospect. The link between technical and tactical innovations and the strategic implications of this type of war, were not to be consciously learnt by the nineteenth century world.⁽⁷²⁾

As time passed after the Civil War, there slowly grew an appreciation of certain technologies, and with these came the gradual adaptation of tactics that built new strategies of warfare. Into these new strategies, future technical innovations evolved that were to shape the wars of the twentieth century.

The inability of concentrated force to easily dislodge the enemy from their defensive positions, was placed in the strategic spotlight. Combined operations and trench warfare provided the focus for those technological changes that could directly circumvent the reliance just upon the strategy of massed frontal assault. The ensuing lessons may not have been consciously absorbed by Civil War commanders, or contemporary European strategists, but today they represent technological and strategic legacies that are impossible to ignore.

71. McNeill, The Pursuit of Power (1983:243)

72. IBID:242

CHAPTER 10: THE CIVIL WAR INNOVATION PROCESS

A cursory analysis of the Civil War innovation process would seem to reveal the absence of any formal structure. The official procurement process in both the North and South were dominated by salesmen, overworked Ordnance Department officers, the absence of any statement on overall military needs, and little capacity to filter the best weapons or ideas from the myriad of lesser options. Nevertheless by wars end improvements to military weapons can be identified. Improvements over the length of the Civil War saw the development, procurement, manufacture, adoption, and deployment of small arms change dramatically from that in existence at the beginning of the war.⁽¹⁾ During the same period naval technology had also made notable advances.

Substantial development work had also occurred in various fields of endeavour such as:

- (i) telegraphy – the Beardslee magno–electric telegraph machine and field telegraphic systems;
- (ii) ballistics and ordnance – fuses, sights, ammunition loads, substitute nitre, trajectory and artillery shell penetration of fixed, solid targets, and explosives;
- (iii) engineering – naval steam propulsion, ironclad ship construction, railway hardware, bridge construction, road construction, and trench-work;
- (iv) medicine – sanitation, diet, and surgery; and
- (v) navigation – hydrography and cartography.

Is it possible to conclude that the many successful innovations that occurred during the Civil War were just isolated advances, not linked by any formal process that encouraged technical improvement?

Stressing the holistic evaluation of technological change, no one technology can be studied in isolation from the context of the overall environment within which technological change occurred. It is, therefore, necessary to examine the general conduct of innovative effort during the Civil War before an insight into the phases of

1. C.L. Davis, Arming The Union (Port Washington, Kennikat Press, 1973:178)

development may be assessed for technical advances. The study of the innovation process is not meant to suggest that wartime Americans (particularly in the North), consciously set up an innovation process, or deliberately organized changes to technology through a systematic process of development. This thesis has already argued against such a conclusion being possible by identifying the inability of Civil War contemporaries to realize the potential of advanced designs, the struggle by successful innovations to be deployed properly on the battlefield, and the incapacity of military organisations to adequately administer military technological changes.

The question is whether a Civil War innovation process can be delineated and its impact on technological change assessed.

10.1 A Model of the Civil War Innovation Process?

The conduct of innovative activity in the Civil War relied heavily upon the efforts of individual innovators who conducted their design work independent of any outside control. Throughout the early years of the war these individuals were responsible for concentrating scientific and technical endeavour. These artisans, independent inventors, craftsmen, and military or marine engineers, produced the innovations that changed existing military technology.(2)

Initially in their backyard barns, and increasingly as the war progressed in company-paid positions, innovators drew upon existing technical knowledge to produce their own military devices. Regardless of the industrial might of the North, the increased role of central government or big companies like Winchester or Du Pont, it was the skill of individual innovators that converted practical know-how into applied research efforts. These effort then formed the basis for industry to produce better and more commercially viable, weapons.(3)

2. J. Ronayne, Science in Government (Australia, Edward Arnold, 1984:10)

3. De Torquville cited D.T. Gilchrist & W.D. Lewis, Economic Changes in the Civil War Era (Delaware, Eleutherian Mills-Hagley Foundation, 1965:117); & J.K. Finch, "Engineering & Science: A Historical Review & Appraisal", Technology & Culture, (Vol.2[4], Fall 1961:327)

In a crude way, individual efforts at innovation were linked together and formed into an enormous body of new knowledge on military technology. It was this technical knowledge that helped form the basis for an innovation process. Discernible phases in innovative endeavour seem to have evolved during the war. In their various attempts to produce military innovations, craftsmen consolidated past advances. In so doing they also created innovations that were to win endorsement and provide the focus for sponsored technological development. The consolidation of industrial and physical resources within the whole process, provided the basis for more co-ordinated development on individual design types. Knowledge became concentrated in research, development, and experimentation. In turn, these efforts served to foster other innovative endeavours. Either directly or indirectly, this pooled knowledge began to spur wider development. As technical knowledge improved, specific development phases became more distinct.

It is perhaps time to revisit the Linear Model and Cyclic Model outlined in Chapter 1. The comparison between the Linear Model and Cyclic Model will provide the framework within which the Civil War innovation process may be identified. This basis can then be expanded to provide a yardstick by which to measure the war's overall contribution to military technological change.

The Linear Model suggests a clear progression to an innovation from the initial demand or pure research spur. The Cyclic Model is far less clear in its progression from any one phase to an innovation. While the Linear Model suggests intervention or direction from a controlling authority, the Cyclic Model is far more interactive. The cyclic process acknowledges that the innovation process may be made up of a number of distinct phases. These may collectively end with the production of a new technological entity or idea, but these phases do not necessarily progress through a logical continuum with a set beginning or finishing point.(4)

4. H.G. Gelber, "Technical Innovation & Arms Control", World Politics (Vol.26[4], July 1974:510)

While the general phases of the cyclic process have the ability to establish wider areas for analysis, they fail to specifically acknowledge other important functions. This is in particular contrast with the Linear Model which places more emphasis upon distinguishing between strategic and pure research, tactical or applied research, and experimental development.

Figure 5 **The Civil War Innovation Process**

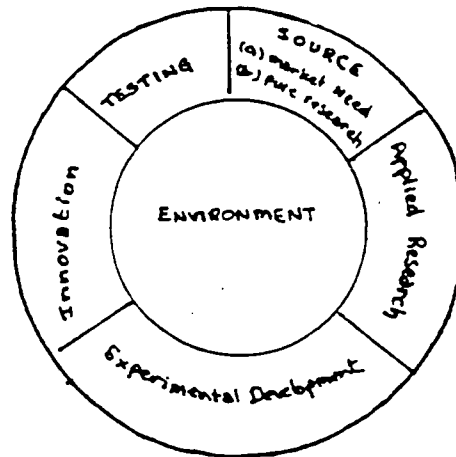


Figure 5 represents an acknowledgement that the Civil War innovation process was not a simple linear process. The phases of development were not controlled for every innovation, nor did development necessarily progress through each distinct phase.

The original spur to innovate in the Civil War was generally left to the company or the innovator. Government or the military played a reactive, rather than pro-active role in technological innovation.⁽⁵⁾ Classically innovations were built upon known technology. This promoted acceptance by officials controlling (or at least influencing) the procurement process. Officials only had on real form of control and this was to issue government contracts that encouraged the production of weapons it was not manufacturing. Hence all the Union forces breech-loaders being made under contract from private providers, for instance. The issuing of contracts was far less likely to be swayed by any minor technological advances over previous designs. The ability of the

5. Davis, Arming The Union (1973:12)

manufacturing firm to supply the arms on time and at a desired level of reliability was of primary importance.(6)

After the first battle of Bull Run in 1861 the Union forces had to face the reality of a protracted armed conflict. This spurred the need to acquire more weapons. Not just weapons that came for the stockpiles of Europe, but more advanced weapons that could be produced by local industry. Between 1862 to 1863 the procurement process is marked by the competition amongst innovations to receive government production contracts. The spur to innovation was increasingly marked by the determination to improve on technology that had gained some degree of acceptance in the initial years of the Civil War. Applied research concentrated on improving the design reliability, its durability in the combat environment, or to make the hardware easier to mass produce. By late 1863 to 1865 the more reliable suppliers with established experience were favoured with contracts for the production of weapons.(7)

The complexity of the unsystematic procurement process meant innovation had great difficulty even securing official endorsement. The applied and experimentation phases to the development of an innovation were, therefore, critical. To build on established designs improved the likelihood of official acceptance, but also guaranteed fewer technical problems the more inventive designs may encounter.

The lack of an effective testing phase in the procurement system consolidated the applied research efforts that sought only to improve known technology. The technology that had already established a military contract formed the guide for further innovative efforts. Thus it was that established demands, not new pure research discoveries, that seems to be the basis for the majority of Civil War military innovations. With the process of military technological change based more on meeting perceived needs, pure scientific work created only a limited basis for devising new technical products through applied research work.

6. IBID:vi

7. IBID:83-84

Interaction between the Civil War innovation process and the environment served only to enforce the individual phases highlighted in the pragmatic model above. As seen in chapter six (on the administration of technological changes), government policy shaped how innovation was undertaken, but it lacked the policies necessary to competently intervene and encourage the better innovations. Without specifically intending to do so, innovation was shaped by policies involving patents, sponsorship of research and development, and the absence of formal testing programmes. This is why the experimental development phase is depicted separately from the applied research phase. It acknowledges that, as research work continued over time, an increased refinement of known technology also occurred. As innovations were designed to conform to the perceived expectations of military officials a distinct experimental development phase eventuated.

Despite the vast array of minor technical developments being accumulated, they only replaced old technology slowly.⁽⁸⁾ This does not deny that the refinement of known, or new technical knowledge, still produced distinct advances. Nevertheless innovators that were keen to produce a commercial design were wary of being too inventive. If any innovation was to return back to the research and development phases the promoter would not only have to undertake re-design at their own expense, but also fight to regain access to the procurement process.

The Gatling Gun is a good example of how a sound innovation did not attain its full potential during the Civil War due to the initial barriers in entering the procurement process. Despite the fact that the Gatling Gun received limited deployment during the initial phases of the war it was not to overcome its inhibiting design faults until 1865.⁽⁹⁾ This situation arose from the fact that the organization of money, manufacturing and technical problems were left to Dr. Richard Gatling to resolve without any direct input from the US Ordnance Department. After subsequent modifications and design

8. A. Zvorikine, "The History of Technology as a Science & As a Branch of Learning: A Soviet View", *Technology & Culture* (Vol.2[1], Winter 1961:2)

9. D. A. Armstrong, *Bullets & Bureaucrats* (Westport, Greenwood Press, 1982:35)

variations it was three years before Gatling once again secured the support of the Washington bureaucracy to have his weapon tested, and later adopted in limited numbers.(10)

However reliable or advanced an innovation may be, there was no guarantee it would receive testing or adoption by the US Ordnance Department. The Spencer Repeating Rifle is a good example of how an very innovative design was derived from proven technical know-how (the Sharps BLR). In addition to his innovation skills the weapons designer, Christopher Spencer, was also an accomplished machinist and salesman. Nonetheless, despite starting to market the weapon to Government in 1862, it was not until May 1864 that an open-end contract was awarded to deliver all the Spencer Carbines they could make until September 1, 1865.(11) This government contract only resulted after the removal of the Chief of Ordnance, Brigadier-General James Ripley, and support received from soldiers already using sizable quantities of the arm in combat.

Civil War innovators worked at more general levels of applied research because of the problem of having to devise new inventions or developments while still ensuring the end product could be sold. This eventually promoted the shift of innovative effort from individual innovators, to those sponsored by larger commercial organizations. Companies could maintain greater entrepreneurial pressure on the military procurement system. They also ensured that the more effort could be spent by innovators or technicians on experimentation or refinement of crude designs. Lone innovators could not continue to bear the on-going expense of refining or developing designs. Nor could smaller entrepreneurs hope to meet government contracts at the volume and deadlines demanded.

It was not uncommon for wartime innovators to sink most of their money into producing a working model. Their ability to refine designs further, often depended on

10. IBID:34 & 36

11. Davis, Arming The Union (1973:93)

government support. Without proper assessment during the testing phase, good designs did not have their faults overcome by government financial assistance. Hence weapons such as the Monitor class vessel and the Henry repeating rifle performed dramatically well in the field and were adopted, despite design faults that could have been overcome with further pre-manufacture work. Other designs such as the US Army Gatling Gun and the CS Army Williams Rapid-Fire Cannon had design flaws that stopped them from being widely adopted. Yet with some design work on specific identifiable problems, both armies could have gained valuable weapons.

Military agencies never recognized how the testing of weapons could be used to refine useful technical innovations.⁽¹²⁾ The testing of innovations was a haphazard exercise that rarely identified a weapon's overall design integrity. Instead testing was used as a negative process, indicating problems not potential. This failure to use testing as a means to refine weapons with technical promise, indicates wider problems with the creation and introduction of new technologies.⁽¹³⁾

The failure in the war's testing phase severely hampered the introduction of better innovations, causing a disjointed advancement in innovative effort. The breakdown at this stage of innovative effort also promoted a greater concentration on research and development as a means to refine existing knowledge. As the full potential of arms such as the Gatling, Monitor, torpedo, and even breech-loading artillery systems, was never fully realised, the designers limited themselves to innovations that could gain easy commercial acceptance.

Throughout the unsystematic innovation process innovations improved upon the previous designs and produced a consistent incremental advance in technology. As arms problems were resolved in steps, each subsequent advance progressed from a basis of growing technical improvement.⁽¹⁴⁾ The final cumulative result was for Civil War to produce an innovation process that lacked any formal direction by outside agencies that

12. IBID:151

13. Armstrong, Bullets & Bureaucrats (1982:36)

14. Davis, Arming The Union (1973:iii)

could enforce systematic progression upon a single innovation, but encouraged overall improvement to existing technology.⁽¹⁵⁾

10.2 Incremental Changes to Military Technology

The course of the Civil War was not influenced by profound technological changes that derived from radical alternatives to existing technical knowledge. Yet the overall scale of technical innovation on Civil War military technology has been clouded by focussing on a few innovations that were supposed to have produced more obvious strategic and technical 'breakthroughs'. There has continually been a failure to recognize how innovations that improved existing technical designs produced an overall impact on technological change. These low-risk designs relied on successive innovations to incorporate their advances. The amazing collection of new designs that incorporated these advancements, prevented the end innovation from being readily identified.

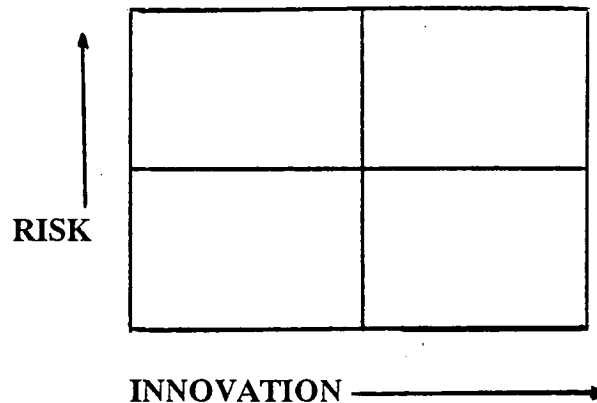
The introduction of new technical knowledge in the Civil War had mixed successes. If it added to the performance of existing technology, an innovation generally had a much better chance of being adopted. For instance ironcladding, BLR cannon designs, and improvements to the telegraph such as the Beardslee or field mobile 'mule' packs. However, if a design made a radical shift away from established technical knowledge, any design weaknesses could limit its successful adoption. If the design also challenged existing technology, the perceived costs of introducing the weapon were considered even more prohibitive. This can be seen with the Gatling Gun, repeating rifles, or high velocity BLR cannons for naval vessels.

The need for weapons, and industry's desire for quick returns, promoted innovations with short time lags before introduction. Hence a concentration of production resources on the manufacturing of established technology, with the search for breakthroughs or undertaking research in high-risk experiments, becoming much less desirable.

15. This was particularly the case with military or government organizations.

Understanding the above factors in relation to the American Civil War confirms the important distinction between radical technological change and conservative technological change. Radical technological change is more likely to derive from pure research efforts, or breakthroughs in research effort. The resulting technological entities usually produce rapid acceleration or changes in developmental directions. Conservative technological change, on the other hand, is more likely to consist of improvements on existing technical knowledge. This results from an innovator's wish to increase the acceptance of the end product. As has been identified as occurring in the Civil War, the emphasis upon applied research efforts reflects an awareness of the need to create harmony with established technology, and to ensure that innovations do not conflict with the traditional biases of those organizations established to manage the technology.

An increase in the control exerted by Civil War governments on the management of military technology procurement improved the ability of innovators to specialize technical effort on certain technologies. The introduction of radical, new technology could not be planned, but with the concentration of technical effort, the risk of conducting more advanced research could be reduced. The over-reliance on applied research work, the unwillingness of innovators to conduct experimentation on designs with no certainty of final adoption, and the lack of a consolidated testing phase, all reflect an innovation environment where uncertainty in demand still dominated the innovation process.

Figure 6 (16)

The above figure is a matrix representation of the barriers to innovation. This is a simple representation of the positive relationship between the degree of innovation and the increase in risk.

Technological change that fell into the lower left area would show a low risk and a low innovation content. This reflects an important distinction between conservative and radical innovations. Conservative innovations being more preferable because of the fewer risks involved in achieving acceptance. More radical innovations based on uncertain technological discoveries, or pure research efforts, have more apparent risk involved for the innovator, and such a technological change would fall into the upper right hand area of the matrix.

Study of the phases in a Civil War innovation process reveal a number of reasons as to why, in this new industrial era, the Civil War only promoted low risk technological changes that were based around existing technical knowledge.

Firstly, for a commercially orientated innovator the risk of creating a dynamic, totally revolutionary technical entity required a great deal of pure research, applied effort, and resources. None of this work was done with any guarantee of military demand, or an accepted measure for assessment. As the natural conservatism of government, industry,

16. R. Landau, "The Innovation Milieu", in S.B. Lundstedt & E.W. Colglazier (eds), Managing Innovation: The Social Dimension of Creativity, Invention & Technology (New York, Pergamon Press, 1982:57)

and particularly the military, was entrenched in the system, there was a reluctance to produce more radical technological changes for formal testing.

Secondly, by adhering to known technology with a proven record or by improving on specifically accepted technological designs, innovators were able to produce innovations that were more likely to take time between development and utilization. The need to refine innovations after achieving some form of testing, would relegate novel designs back to the beginning of the process.

Thirdly, as there existed no formal co-ordinating agency or systematic testing phase, the standard of excellence in innovation was uncertain. This often restricted the promotion of good designs, further limiting the 'pool' of available technical knowledge and tightening the cyclic promotion of future innovations.

The informal adoption, trial, and contract systems, negated any efforts made by government to intervene to enhance an innovation at any stage of the innovation process. In particular, there existed a clear lack of comprehension as to how official measures could shorten the period between development of a basic (needed) design and its use by the military.

For the fourth point it may be argued that, had authorities recognized the potential of good innovations at point of initial conception (applied research phase of the Civil War innovation process model), refinement of technical knowledge could have occurred more quickly. This awareness may also have permitted earlier acceptance and therefore greater research effort on the generative technical knowledge. Had there been broad based testing and development in a design area, it is plausible to suggest that less lags would have occurred between the commitment of manufacturing resources and final utilization of the technology.

The fifth reason why conservative changes to military technology may have occurred, resulted from the Civil War innovation effort being faced with trying to control all the developments being spurred by each new technological change. Defensive tactics meant

that at sea, emphasis was placed on developing increased firepower, rams, and effective armour-plating. On land, the use of trenches promoted development of guns with longer ranges, which in turn necessitated better-designed defensive positions. In industry, better and larger arms requirements, promoted larger hydraulic and machine-tool equipment. This necessitated greater steam power, better electrical systems, and improved organization.⁽¹⁷⁾ Science, despite failing to limit the parameters of applied research through effective pure research, also contributed to the production of military technology.⁽¹⁸⁾

What evolved was a process of cyclic influences that stimulated an unprecedented linkage between industrialisation and military innovation. Yet, as the study of the Civil War innovation process has illustrated, the absence of clear direction promoted the focussing of research onto known technological entities.

The process of innovation in the Civil War was for the most part unco-ordinated, with little direct government policy support. A study of Civil War innovations, their environment, and then the pragmatic models of examination used here, all indicates a moderate increase in technical knowledge. As innovations improved the viability of certain technical fields, design work gradually became more co-ordinated on specific endeavours.

Because the introduction of innovations was not systematically controlled by government, some modern analysts have condemned the Civil War for being unscientific. Evidence is not hard to find for the contention that the war was pre-modern in both its application of scientific knowledge, and the subsequent exploitation innovations derived from pure research work.

To establish the modernity of the war it is simply not a worthwhile exercise to just identify radical breakthroughs or emphasise pure research. Through incremental

17. W.H. McNeill, *The Pursuit of Power: Technology, Armed Force & Society Since AD 1000* (Oxford, Basil Blackwell, 1983:241)

18. G.I. Rochlin (ed), *Readings from Scientific American* (San Francisco, W.H. Freeman, 1974:2)

stages, Civil War military technology did change, resulting in the creation of new dimensions to warfare that surpassed all previous experiences.

IMPACT OF TECHNOLOGICAL CHANGE SUMMARY

Despite the almost imperceptible nature of the technological change, innovations fundamentally altered the means available to wage war. The study of the innovation process illustrates that the myriad of alterations, improvements, and specific developments in military technology contributed to the expanding pool of technical knowledge. Despite innovations not always being successful or their full potential being realised, they did influence the technical knowledge available for later innovators to draw from.

During the Civil War new technical skills and knowledge were increasingly required by the military to wage war. Not only did armies have to include civilian personnel in their ranks to operate technology, military officers and soldiers had to adopt new skills so as to exploit improved military tools. The relationship between government and rail companies especially reflected the first real co-operation by the State with a large company that had grown out of the Industrial Revolution. The fate of military effort on the battlefield necessitated a continuous relationship between the public and private rail interests throughout the Civil War.(19)

The deployment of the rapid firing gun stands testimony to the progress some military minds made in dealing with new technology. In 1861 J D Mills sought to sell his Union Repeating Gun (Ager Gun) to the North. Not only were his efforts blocked by a reluctant Ordnance Department, field officers that tested the weapon lacked both the technical skills to even assess the merits of the weapon, and the comparative knowledge necessary to assess how the weapon could "fit" with existing military doctrine.(20) By 1865, however, Union naval officers were encouraging the design and deployment of a Gatling Gun with a 1-Inch bore. Senior naval officers had recognized the weapon had

19. M. Pearton, *The Knowledgeable State* (London, Burnett Books, 1982:77)

20. Armstrong, *Bullets & Bureaucrats* (1982:18-21)

improved with the use of brass cartridges, but more importantly it could be fitted on a specially designed mounting aboard their vessels and used to repel torpedo boats.

The imperceptible advance of military technology was coupled with an increase in the population's general appreciation of technical innovation. While repeating weapons, iron clad vessels, the telegraph, and railroads may not have been well understood as technological entities, they produced visible contributions to the war effort. As key technologies did succeed in gaining military deployment they confirmed the value of technical change in the minds of both government and the general public.

Innovative endeavours began to concentrate on utilizing proven and accepted technology as the basis for further commercial products. In so doing weapons technology moved into an era marked by breech-loading ordnance, vastly improved ammunition, iron cladding, steam power, aerial observation, and better strategic and tactical communications. Together, these endorsed technical innovations or techniques, altered the characteristics of warfare. They introduced fundamental concepts alongside the technical realities that were to produce the basis for modern industrialized wars of the twentieth century.(21)

The legacy of Civil War technical innovation is such that it can, in retrospect, be discerned as an important transition point between previously traditional wars and the more modern wars of the twentieth century.

21. McNicill, The Pursuit of Power (1983:260–261)

CONCLUSION

To understand military technological change properly it is necessary firstly to place any study into a wider historical context. Only in this context is it possible to trace the series of changes to technical knowledge, and assess the future importance of the end technology. The impact of a technology, at a given point in time and place, can then be fully appreciated by studying it as a function within a specific environment: being influenced by, and in turn influencing, society.

During the Civil War it seems that neither the immediate impact of a technology, nor the advancement in technical knowledge, represent appropriate indicators of an innovations' ultimate importance. A technology like the Rodmans/Dahlgren MLR cannon produced an immediate impact on Civil War conflict, but held significantly less value for future technical developments. Other innovations such as the BLR small-arms produced seemingly unimportant, incremental improvements to technology, but eventually they consolidated to produce more reliable technological entities such as the Spencer and Henry repeating rifles. Minor technical changes were also responsible for gradually reducing the barriers of acceptance certain technologies faced, or permanently altering the military utility of a technology.

This thesis has supported a more holistic method for understanding military technological change. By firstly identifying key military innovations, it was then possible to examine the impact non-technical factors had on the adoption and further development of a technology. After progressing through these stages it then became feasible to conduct an assessment on how these technologies added to existing technical knowledge and the military's strategic operations.

A more balanced assessment of an innovation necessitates the consideration of environmental factors. It is the study of non-technical factors that often provide clues as to why some innovations were not widely deployed. The significance of these constraints, their impact on innovation, and their influence on how history has come to perceive Civil War lessons has not been given enough weight. Too often the emphasis is only placed upon those weapons that went into production. Such an approach is likely to overlook the contribution pre-war technical developments made to technologies that were first placed into production during the war. Concentration on weapons that went into production can also lead to a lack of emphasis being placed on successful wartime designs that were not widely produced due to non-technical barriers.

A study of the Civil War confirms that the introduction of technically advanced weapons into war, does not determine the immediate importance of that technology.

The Monitor is one technology that is held to be a landmark in military history. Yet its technical legacy can be attributed more to the deliberate incorporation of existing technical advances into one design, rather than a breakthrough in technical knowledge. This contrasts with the Gatling Gun, which produce a totally unique technology by incorporating many novel technical ideas together. Nevertheless, it was not deployed to any great effect during the Civil War.

The importance of innovations in railroads, ironclad warships, telegraphic communications, and balloon technology, do not appear as great when considered in the context of overall Civil War innovative effort. Rather than trying to acclaim all these technological changes as radical improvements, which they mostly were not, their importance as examples of core technologies needs to be stressed. It was the incremental improvements, made by innovations upon them, that made these core technologies more effective military tools.

Many technological changes confirmed the importance of on-going technical developments in areas that were still to be fully appreciated by Civil War contemporaries. To realize the future technical value of some designs not widely adopted in the war, one only has to examine the post-war impact of the lever action repeating rifles, revolver technology, and field-telegraph communication systems.

Other important Civil War technical developments had to await future wars before their true merit could be realized. The importance of the torpedo and of related technology, the value of rapid-fire field guns (the machine-gun), BLR cannons, and development of hollow artillery projectiles that could carry chemical substances, were not effectively established until after the Civil War.

To appreciate the wartime advancement in military technology fully, one must simultaneously study the use of innovations in arms, entrenchment, and tactics, at Petersburg in 1864. The dimensions and ferocity of the Petersburg conflict can be held as a clear precursor to the First World War.⁽¹⁾ One of the problems with assessing the modern nature of the Civil War may, however, reside with analysts looking to the First World War as a comparative modern war. This is done, apparently, because it illustrates the importance of scientific endeavour, and the systematic introduction of technology in a total war. But one may seriously question the basis for such an argument. With the exception of air warfare, strategists and tacticians were still utilizing weapons with known technological dimensions. They were using these weapons over ranges, and in manners, that were well established in military annals.⁽²⁾

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1. K. Macksey, Technology in War (London, Arms & Armour Press, 1986:28)
 2. S. Zuckerman, Scientists & War (London, Scientific Book Club, 1966:113)

Regardless of parallels the Petersburg campaign had with the First World War, history has not been overly considerate of the overall technical legacy left by the Civil War. Many important advances in technology were overlooked by contemporaries of the war. While the lessons, that could have been learnt by European armies from the impact of new technology on the conduct of Civil War, had to be re-learnt over the next fifty years.

It would be misleading, however, if we were to limit the legacy of the Civil War because we continue to measure the war's modern proportions, by seeking to identify a few innovations that may fit the mould of radical technological change. It is not sufficient to apply the modern war title simply because there were produced a few innovations that derived from scientific research and had never before been identified in military history.

Admittedly science set the scope of novel technological changes in the Civil War. The new era of science had utilized pure research to establish a basis of theoretical knowledge that technologists built their practical innovations from. However, with military technological change playing no significant role in redirecting pure research work, scientific endeavour mostly drew upon knowledge already in existence prior to the Civil War.

Through the use of applied research efforts, innovators drew from the past designs and from existing research efforts to advance military technological understanding. This serves to make the Civil War an unreliable example of a scientific war that was brought on by a new era of military hardware derived from pure research.⁽³⁾ With the prevalence of barriers and delays in acceptance, those new technologies that were introduced contributed little of substance to the advancement of theoretical science. This ultimately served to stifle rapid technical advances and increase reliance solely upon applied research efforts.

As the application of scientific knowledge and the systematic exploitation of innovations is held to be a feature of twentieth century wars, the Civil War is therefore believed to be pre-modern. This failure of innovation to be systematically introduced, has caused some modern analysts to deprecate the war as being unscientific.

This thesis has stressed the importance of acknowledging that the process of innovation in the Civil War was mostly unco-ordinated, with little direct government policy support. The bulk of the technological changes, impacting on the conduct of the Civil

3. G.I. Pokrovsky, *Science & Technology in Contemporary War* (London, Atlantic Books, 1959:3)

War, were conducted by individual innovators using applied research to make only modest additions to existing fields of technical knowledge.

Technology change that did occur mostly progressed through a series of cautious innovations, building on established technical knowledge. The study of innovations, their environment, and then the pragmatic models of examination used here, all reflect a gradual increase in technical knowledge. Only after two years of war did the concentration of innovative effort on key areas of design, and the increasing desire to fill specific needs, directly promote the co-ordinated development of certain technological advances.

It is evident that the ability to design and produce a superior technological entity, was not enough. Institutional barriers to innovation played a significant role in determining the success of a technology. Certain important innovations were never able to achieve their full potential because military institutions were unable to discern those technologies that would be most appropriate to their needs.

The Civil War confirms the basic contradiction between the progress of military technical knowledge, and the need to prove certain technologies' combat potential. On the one hand, there exist lags in nurturing innovations by military organizations, and on the other hand, the failure, by these same institutions, to integrate the best designs into their strategic considerations. The resolution of this fundamental contradiction was to be addressed in the modern wars of the twentieth century.⁽⁴⁾ It is in the Civil War that the first attempt was made in the industrial age to co-ordinate the innovation process towards set ends. Therefore, a study of military technological change produces more illuminating lessons for the subsequent wars than for the preceding conflicts.

Perhaps the most important finding that can be made, from a study of military technological change in the Civil War, is that innovations seem to have drawn from existing technical knowledge and produced low-risk, incremental design advancements. The study of military technological change as an environmental function confirms that the adoption of new technology was affected by the ability of military organizations, and the civil bureaucracy, to recognize its potential and sustain its use. Conservative innovations, that had only a limited capacity to challenge established organizational values and the technical expertise of field commanders, were more likely to be accepted.

The Civil War can undoubtedly be seen as a harbinger of technological change and, in retrospect, may be seen as the transition point between traditional wars of the nineteenth century and modern wars of the twentieth century. Nevertheless, the era of

4. A point originally set out by John Ellis' study on The Social History of the Machine Gun (London, Cresset, 1975:177)

modern war did not dawn with the ending of the war. Civil War technological advances, whether adopted or not, produced a legacy of technical know-how that was to irrevocably alter armed conflict after 1861.

BIBLIOGRAPHY

- G. B. Abdill,
Civil War Railroads (New York, Bonanza Books, 1961)
- E.D. Adams,
Great Britain & the American Civil War (Volume I & II) (New York, Russell & Russell, 1924)
- G.W. Adams,
Doctors in Blue: A Medical History of the Union Army in the Civil War (New York, Henry Schuman, 1952).
- J. Agassi,
"The Confusion Between Science & Technology in the Standard Philosophies of Science", Technology & Culture (Vol.7, No.3, Summer 1966:348-366)
- J. Agassi,
Science in Flux (Boston Studies in the Philosophies of Science, Vol. 28, Boston, Reidel, 1975)
- D.C. Allard,
"Naval Technology During the American Civil War", The American Neptune (Vol.49, Spring 1989:114-122)
- B. Anderson,
By Sea & By River: The Naval History of the Civil War (New York, Alfred A. Knopf, 1962)
- R. Andreano (ed),
The Economic Impact of the American Civil War (Cambridge, Schenkman, 1967)
- D. A. Armstrong,
Bullets & Bureaucrats: The Machine Gun & The United States Army, 1861-1916 (Westport, Greenwood Press, 1982)
- P. Battey, & P. Parish,
The Divided Union: The Story of the Great American War, 1861-1865 (Topsfield, Salem House, 1987)
- Battles & Leaders of the Civil War,
(Reprint of Century Magazine War Series, 1889)
(4 Vol.) (New Jersey, Castle, 1980)
- J.S. Barnes,
Submarine Warfare, Offensive & Defensive (New York, Van Nostrand, 1869)
- J.P. Baxter III,
The Introduction of the Ironclad Warship (Cambridge, Harvard University Press, 1933)

- M. Beloff,
"Great Britain & the American Civil War", Historical Revision No.CXVIII, History (Vol.37, 1959:40-48)
- R.E. Beringer, H. Hattaway, A. Jones, & W.N. Still,
Why the South Lost the Civil War (Athens, University of Georgia Press, 1986)
- Blackwoods Edinburgh Magazine,
Editorial on "Who Planned the Monitor?"
(Vol.91[560], June 1862)
- C. Blair (ed),
Pollard's History of Firearms (New York, MacMillan, 1983)
- C. Boyle, P. Wheale & B. Surgess,
People, Science & Technology: A Guide to Advanced Industrial Society (London, Wheatsheaf Books, 1984)
- T.C. Bridges,
The Book of Invention (London, George G. Harrap, 1925)
- W.R. Brock (ed),
The Civil War (New York, Harper & Row, 1969)
- W.R. Brock,
Conflict & Transformation: The United States 1844-1877 (London, Penguin, 1978)
- D. Brogan,
"The Debate on the American Civil War", Proceedings of the British Academy (Vol.49, 1963:203-232)
- H. Brogan (ed),
The American Civil War: Extracts from The Times 1860-1865 (London, Times Books, 1975)
- H. Brooks,
"Technology, Evolution & Purpose", Daedalus
(Vol.109[1], Winter 1980:65-82)
- R.S. Brownlee,
Gray Ghosts of the Confederacy: Guerrilla Warfare in the West, 1861-1865 (Baton Rouge, Louisiana State University Press, 1968)
- R.V. Bruce,
Lincoln & the Tools of War (Westport:Connecticut, Greenwood Press, 1973)
- R.F. Burgess,
Ships Beneath the Sea: A History of Subs & Submersibles (New York, McGraw-Hill, 1975)
- A.H. Burne,
Lee, Grant & Sherman (London, Scribner, 1938)

- D.F. Butler,
United States Firearms: The First Century, 1776-1875
(New York, Winchester Press, 1971)
- A.H. Campbell,
"The Lost War Maps of the Confederates", The Century Magazine (Vol.35[3], January 1888:479-480)
- B. Catton,
The American Heritage Short History of the Civil War
(New York, Laurel-Leaf Library, 1972)
- A.F. Chalmers,
What is this Thing Called Science? (St. Lucia,
Queensland University Press, 1982)
- D.G. Chandler,
Atlas of Military Strategy: The Art, Theory &
Practice of War, 1618-1878 (London, Arms & Armour,
1980)
- C. Chant,
How Weapons Work (London, Marshall Cavendish, 1980)
- W.S. Churchill,
The American Civil War (London, Cassell, 1958)
- Civil War Naval Chronology 1861 - 1865 ,
(Six Parts, Including Index) (Washington DC, Office
of the Chief of Naval Operations, Naval Department,
Undated - circa 1965)
- V.S. Clark,
History of Manufactures in the United States
(Vol.II) (Washington D.C., Carnegie Institute of
Washington, 1928)
- C. Von Clausewitz,
On War (Anatol Rapoport Editor) (London, Penguin,
1984)
- J. C. Cobb,
Industrialization & Southern Society 1877-1984
(Lexington, Kentucky University Press, 1984)
- J. Coggins,
Arms & Equipment of the Civil War (Garden City: New
York, Double Day, 1962)
- I.B. Cohen,
"Science & the Civil War", Technology Review
(Vol.48, 1946:167-170 & 192-193)
- R.S. Cohen, P.K. Feyerabend, & M.W. Wartofsky (ed),
Essays in Memory of Imre Lakatos (Boston Studies in
the Philosophy of Science, Vol.39) (Boston, Reidel,
1976)

- C.B. Colby,
Civil War Weapons: Small Arms & Artillery of the Blue & Grey (New York, Coward-McCann, 1962)
- B. Collins,
The Origins of the American Civil War (London, Edward Arnold, 1981)
- H.S. Commager,
The Blue & the Grey (Vol.I) (Indianapolis, Bobbs, 1950)
- H.S. Commager, M. Cunliff & M.A. Jones (eds),
Illustrated History of the American Civil War (London, Orbis, 1976)
- J.S. Corbett,
Some Principles of Maritime Strategy (London, Longmans, Green & Co., 1911)
- H.H. Cunningham,
Doctors in Grey: The Confederate Medical Service (Baton Rouge, Louisiana State University Press, Second Edition 1960)
- W.B. Cushing (Commander USN),
"The Destruction of the Albemarle", (Part III) of
"The Career of the Confederate Ram Albemarle", The Century Magazine (Vol.36[3], July 1888:432-438)
- G.H. Daniels,
"The Big Questions in the History in American Technology", Symposium: The Historiograph of American Technology, Technology & Culture (Vol.11[1], January 1970:1-21)
- G.H. Daniels (ed),
Nineteenth-Century American Science: A Reappraisal (Evanston, Northwestern University Press, 1972)
- C.L. Davis,
Arming the Union: Small Arms in the Civil War (Port Washington, Kennikat Press, 1973)
- B. Davis,
Sherman's March (New York, Random House, 1980)
- J. Davis,
"Lord Wolseley's Mistakes", North American Review (Vol.149[397], November 1889)
- E. De Bono (ed),
Technology Today (London, Routledge & Kegan Paul, 1971)
- F.V.A. De Chanal,
The American Army in the War of Secession (Leavenworth: Kansas, Spooner, 1894)

- N. De Nevers,
Technology & Society (Massachusetts, Addison-Wesley, 1972)
- D.J. De Solla-Price,
Little Science, Big Science (New York, Columbia University Press, 1963)
- Department of the Army,
ROTC Manual 145-20: American Military History 1607-1958 (United States of America, Headquarters Department of the Army, July 1959)
- D J De Solla-Price,
"Is Technology Historically Independent of Science? A Study in Statistical Historiography", Technology & Culture (Vol.1, 1966:553-568)
- C. Dilworth,
Scientific Progress: A Study Concerning the Nature of the Relation Between Successive Scientific Theories (Studies in Epistemology, Logic, Methodology, & Philosophy of Science, Vol.15) (London, Reidel, 1981)
- C. Dixon,
Ships of the Victorian Navy (Southampton, Ashford Press Publishing, 1987)
- D. Donald (ed),
Why the North Won the Civil War (Louisiana, Louisiana State University Press, 1960)
- R.W. Donnelly,
"Rocket Batteries of the Civil War", Military Affairs (Vol.25[2], Part 2, 1961:69-93)
- F.D. Downey,
The Guns at Gettysburg (New York, Collier Books, 1962)
- P.F. Drucker,
"The Technological Revolution: Notes on the Relationship of Technology, Science & Culture", Technology & Culture (Vol.11[4], Fall 1961:342-351)
- P.F. Drucker,
"Comments: Is Technology Predictable?", "Symposium: The Role of Technology in Society", Technology & Culture (Vol.10, No.4, October 1969:522-527)
- J. Dunn,
"The Marlin Ballard Rifle", Australian Shooters Journal (April 1987:36-39)

- A. Hunter-Dupree,
Science in the Federal Government: A History of Policies & Activities to 1940 (Cambridge: Massachusetts, Belknap Press of Harvard University Press, 1957)
- A. Hunter-Dupree,
 "The History of American Science", American Historical Review (Vol.71, No.3, April 1966:863-874)
- E.M. Earle (ed),
Makers of Modern Strategy: Military Thought from Machiavelli to Hitler (Princeton, Princeton University Press, 1973)
- S.E. East,
 "Montgomery C. Meigs & the Quartermaster Department", Military Affairs (Vol.25[4], Winter 1961-62:183-196)
- C. Eaton,
A History of the Southern Confederacy (New York, Free Press, 1954)
- G. Elliot,
 "Her Construction & Service" (Part I) of "The Career of the Confederate Ram Albemarle", The Century Magazine (Vol.36[3], July 1888:420-427)
- J. Ellis,
The Social History of the Machine Gun (London, Cresset Library, 1975)
- J. Ellul (Translated by J. Wilkinson),
The Technological Society (New York, Alfred A. Knopf, 1976)
- S. Encel & J. Ronayne (eds),
Science, Technology & Public Policy: An International Perspective (Australia, Pergamon Press, 1979)
- S. Engelbourg,
 "The Economic Impact of the Civil War on Manufacturing Enterprise", Business History (Vol.21[1-2], 1979:148-162)
- S.L. Engerman,
 "The Economic Impact of the Civil War", Explorations in Entrepreneurial History (Vol.3[3], Spring 1966:176-199)
- P. D. Escott,
After the Secession: Jefferson Davis & The Failure of Confederate Nationalism (Baton Rouge, Louisiana State University Press, 1978)
- E. Ezell,
Handguns of the World (London, Arms & Armour, 1981)

- D.G. Faust,
The Creation of Confederate Nationalism (Baton Rouge, Louisiana State University Press, 1988)
- J.K. Feibleman,
"Pure Science, Applied Science, Technology : An Attempt at Definitions", Technology & Culture (Vol.2[4], Fall 1961:305-317)
- P Feyerabend,
Against Method: Outline of an Anarchistic Theory of Knowledge (London, Verso, Seventh Impression 1987)
- J.K. Finch,
"Engineering & Science: A Historical Review & Appraisal", Technology & Culture, (Vol.2[4], Fall 1961:318-332)
- A. Fishlow,
American Railroads & the Transformation of the Anti-Bellum Economy (Cambridge: Massachusetts, Harvard University Press, 1965)
- E.D. Fite,
Social & Industrial Conditions in the North During the Civil War (New York, Frederick Ungar, 1963)
- R.W. Fogel,
Railroads & American Economic Growth: Essays in Econometric History (Baltimore, John Hopkins Press, 1964)
- W.F. Fox,
"The Chances of Being Hit in Battle: A Study of Regimental Losses in the Civil War", The Century Magazine (Vol.36[1], May 1888:93-106)
- J.H. Franklin,
Reconstruction: After the Civil War (Chicago, Chicago University Press, 1961)
- J.A.L. Fremantle (Lt.Col.),
"A Month's Visit to the Confederate HQ", Blackwoods Edinburgh Magazine (Vol.92[567], January 1863)
- J.B. Fry,
"Lord Wolseley Answered", North American Review (Vol.149[397], December 1889:728-740)
- C.E. Fuller & R.D. Steuart,
Firearms of the Confederacy (Huntington: West Virginia, Standard, 1944)
- J.F.C. Fuller,
The Generalship of Ulysses S. Grant (New York, Dodd - J. Murray, 1929)

- J.F.C. Fuller,
"The Place of the American Civil War in the
Evolution of Warfare", Army Quarterly (Vol.26,
1933:316-325)
- J.F.C. Fuller,
Armament & History (London, Eyre & Spottiswoode,
1946)
- J.F.C. Fuller,
The Decisive Battles of the Western Worlds (Vol.III)
"From the American Civil War to the End of the
Second World War" (London, Eyre & Spottiswoode,
1956)
- E. Garfield,
Citation Indexing - Its Theory & Application in
Science, Technology, & Humanities (New York, John
Wiley & Sons, 1979)
- H.G. Gelber,
"Technical Innovation & Arms Control", World
Politics (Vol.26[4], July 1974:509-541)
- D.T. Gilchrist & W.D. Lewis,
Economic Changes in the Civil War Era Proceedings of
a Conference on American Economic Institutional
Change, 1850-1873, & The Impact of the Civil War
(Greenville: Delaware, Eleutherian Mills-Hagley
Foundation, 1965)
- J.T. Glatthaar,
The March to the Sea & Beyond: Sherman's Troops in
the Savannah & Carolinas Campaign (New York, New
York University Press, 1985)
- M. Glover,
Warfare from Waterloo to Mons (London, Cassell,
1980)
- R. Goff,
Confederate Supply (Durham, Duke University Press,
1969)
- C. Goldin & F. Lewis,
"The Economic Cost of the American Civil War:
Estimates & Implications", Journal of Economic
History (Vol.35[2], June 1975:299-326)
- P. Griffith,
Rally Once Again: Battle Tactics of the American
Civi War (Wiltshire, Crowood Press, 1987)
- L.C. Grey,
History of Agriculture in Southern United States
to 1860 (Washington D.C., Carnegie, 1933)

- W. Greenleaf (ed),
American Economic Development Since 1860 (New York, Harper Torchbooks, 1968)
- The Gun Digest
 (12th Edition) (New York, American Publishing House, 1958)
- H.J. Habakkuk,
American & British Technology in the Nineteenth Century: A Search for Labour-saving Inventions (Cambridge, Cambridge University Press, 1962)
- F.W. Hackley,
Report on Civil War Explosive Ordnance (Indian Heads: Maryland, U.S. Naval Propellant Plant, 1960)
- E. Hagerman,
 "From Jomini to Denis Hart Mahan: The Evolution to Trench Warfare and the American Civil War", Civil War History (Vol.13, September 1967:197-220)
- E. Hagerman,
 "Field Transportation & Strategic Mobility in the Union Armies", Civil War History (Vol.34[2], June 1988:143-171)
- E. Hagerman,
The American Civil War & The Origins of Modern Warfare: Ideas, Organizations, & Field Command (Bloomington, Indiana University Press, 1988)
- W.R. Hamilton,
 "American Machine Cannon & Dynamite Guns", The Century Magazine (Vol.36[6], October 1888:885-893)
- R.R. Hardy,
 "The Use of Explosive Bullets", Civil War Times Illustrated (Vol.5[6], October 1966:43-45)
- H. Hattaway & A. Jones,
 "The War Board, The Basis of the United States First General Staff", Military Affairs (Vol.46[1], Feb. 1982:1-6)
- H. Hattaway & A. Jones,
How the North Won: A Military History of the Civil War (Urbana, University of Illinois Press, 1983)
- D.C. Hay, T.L. Anderson & P.J. Hill,
Growth & Welfare in the American Past: A New Economic History (Englewood Cliffs: New Jersey, Prentice-Hall, Third Edition 1983)

- F.S. Haydon,
Aeronautics in the Union & Confederate Armies: With a Survey of Military Aeronautics Prior to 1861 (2 Vol.) (Baltimore, A Doctoral Dissertation submitted to the Board of Universities Studies of the John Hopkins University, 1941)
- J.C. Hazlett,
 "Parrott Guns in the Civil War", Civil War Times Illustrated (Vol.5[7], November 1966:27-33)
- C.G. Hempel,
Philosophy of Natural Science (Englewood Cliffs: New Jersey, Prentice-Hall, 1966)
- G.F.R. Henderson,
The Campaign of Fredericksburg November-December 1862: A Tactical Study for Officers (Aldershot, 1891)
- G.F.R. Henderson,
Stonewall Jackson & The American Civil War (Vol.I & II) (London, Longmans & Green, Second Edition 1902)
- E.J. Hess,
 "Northern Response to the Ironclad: A Prospect for the Study of Military Technology", Civil War History (Vol.31[2], June 1985:126-143)
- R. Hofstadter (ed),
Great Issues in American History, (Vol.II) "From the Revolution to the Civil War, 1765-1865" (New York, Random House, 1958)
- I.V. Hogg & J. Batchelor,
A History of Artillery (London, Hamlyn, 1974)
- I.V. Hogg & J. Batchelor,
The Machine-Gun (Purnell's History of the World Wars Special) (London, Phoebus, 1976)
- E. Holdern,
 "The Albemarle" & the Sassacus An Attempt to Run Down an Iron-Clad with a Wooden Ship", The Century Magazine (Vol.36[3], July 1888:427-432)
- D.A. Hollinger,
 "T.S. Kuhn's Theory of Science & its Implications for History", American Historical Review (Vol.78, No.2, April 1973:370-393)
- A. Holley,
A Treatise on Ordnance and Armour (New York, Van Nostrand, 1865)
- R.S. Holmes (ed),
The World Atlas of Warfare: Military Innovations that Changed History (London, Guild Publishing, 1988)

- W.S. Hoole,
 "The Confederate Armory at Tallassee, Alabama, 1864-1865", The Alabama Review (Vol.25[1], January 1972:3-29)
- M. Howard,
The Franco-Prussian War: The German Invasion of France 1870-71 (London, Rupert-Davis, 1962)
- M. Howard,
The Theory and Practice of War: Essays Presented to Capt. B.H. Liddell-Hart (London, Cassell, 1965)
- M. Howard,
War in European History (London, Oxford University Press, 1976)
- M. Howard,
 "War & Technology", Journal of the Royal United Services Institute For Defence Studies (Vol. 132[4], December 1987:17-22)
- H.R. Howland,
 "An Anecdote of the Petersburg Crater", The Century Magazine (Vol.34[2], December 1888:323)
- P.A. Hutton,
Phil Sheridan & His Army (Lincoln, University of Nebraska Press, 1985)
- B. Jenkins,
Britain & the War for the Union (Vol.I) (Montreal, McGill-Queen's University Press, 1974)
- L.H. Johnson,
 "Civil War Military History: A Few Revisions in Need of Revision", Civil War History (Vol.17, 1971: 115-130)
- A. Jones,
 "Jomini & the Strategy of the America Civil War, A Reinterpretation", Military Affairs (Vol.34[4], December 1970:127-131)
- V.C. Jones,
The Civil War At Sea (3 Vols.)
 (Vol.I) "January 1861-March 1862 - The Blockaders"
 (Vol.II) "March 1862-July 1863 - The River War"
 (Vol.III) "July 1863-November 1865 - The Final Effort"
 (New York, Holt, Rinehart & Winston, 1960/1961 & 1962 Respectively)
- H. Joules (ed),
Doctors' View of War (London, G. Allen & Unwin, 1938)

- A. Kaplan,
The Conduct of Inquiry: Methodology for Behavioral Science (California, Chandler, 1964)
- D. W. Knox,
"River Navies in the Civil War" Military Affairs
(Vol.28[1], Spring 1954:29-32)
- M. Kranzberg,
"Technology & History: 'Kranzberg's Laws'",
Technology & Culture (Vol.27[3], July 1986:544-560)
- W.P. Kremer,
100 Great Battles of the Rebellion (New Jersey,
Hoboken, 1906)
- T.S. Kuhn,
"The History of Science", International Encyclopedia
of the Social Sciences (No.14, 1968:74-83)
- T.S. Kuhn,
The Structure of Scientific Revolutions
(International Encyclopedia of Unified Science
Vol.2, No.2 - Chicago, Chicago University Press,
Second edition, 1975)
- E.M. Law,
"From the Wilderness to Cold Harbour", The Century
Magazine, (Vol.34[2-39], June 1887:277-301)
- O. Layriz,
Mechanical Traction in War (London, David & Charles
Reprint, 1973 - reprint of 1900)
- R.A. Leonard,
A Short Guide to Clausewitz On War (London
Weidenfeld & Nicolson, 1967)
- B.R. Lewis,
Notes on Ammunition of the American Civil War :
1861-1865 (Washington, American Ordnance
Association, 1959)
- B.H. Liddell-Hart,
Sherman the Genius of the Civil War (London, Dodd,
1930)
- B.H. Liddell-Hart,
Strategy: The Indirect Approach (London, Faber &
Faber, 1967)
- S.B. Lundstedt & E.W. Colglazier (eds),
Managing Innovation: The Social Dimension of
Creativity, Invention & Technology (New York,
Pergamon Press, 1982)
- J. Luvaas,
"G.F.R. Henderson & The American Civil War",
Military Affairs (Vol.20[3], Fall 1956:139-153)

- J. Luvaas (ed),
The Civil War: A Soldier's View (A Collection of Civil War Writings by Col. G.F.R. Henderson) (Chicago, University of Chicago Press, 1958)
- J. Luvaas,
The Military Legacy of the Civil War: The European Inheritance (Chicago, University of Chicago Press, 1959)
- J. Luvaas,
The Education of an Army: British Military Thought, 1815-1940 (Chicago, University of Chicago Press, 1970)
- C.W. MacCord,
 "Ericsson & His Monitor", North American Review (Vol.149[395], December 1889:460-471)
- J. MacDonald,
Great Battles of the American Civil War (London, Guild Publishing, 1988)
- K. Macksey,
Technology in War: The Impact of Science on Weapon Development & Modern Battle (London, Arms & Armour Press, 1986)
- D.H Mahan,
A Summary of the Course of Permanent Fortifications & the Attack & Defence of Permanent Fortifications (Richmond, West & Johnston, 1863)
- J.K. Mahon,
 "Civil War Infantry Assault Tactics", Military Affairs (Vol.25[2], Part I, Summer 1961:57-68)
- N. Malcolm (ed),
The Science of War: A Collection of Essays & Lectures, 1891-1903: By the late Colonel G.F.R. Henderson (London, Longmans, Green & Co., 1910)
- F. Maurice,
Robert E. Lee: The Soldier (New York, Houghton, 1925)
- O. Mayr & R.C. Post (eds),
Yankee Enterprise: The Rise of the American System of Manufactures A Symposium Sponsored by the U.S. Chamber of Commerce (Washington D.C., Smithsonian Institution Press, 1981)
- R. McBride,
Civil War Ironclads: The Dawn of Naval Armour (New York, Chilton Books, 1962)
- J.L McDonough & J.P. Jones,
War So Terrible: Sherman & Atlanta (New York, W W Norton, 1987)

- R.H. McLean,
"Troop Movements on American Railroads During the Great War", American Historical Review (Vol.26[3], April 1921:464-488)
- W.H. McNeill,
The Pursuit of Power: Technology, Armed Force & Society Since AD 1000 (Oxford, Basil Blackwell, 1983)
- J.M. McPherson,
Ordeal By Fire: The Civil War & Reconstruction (New York, Alfred A. Knopf, 1982)
- G. McWhinney,
"Who Whipped Whom? Confederate Defeat Re-examined", Civil War History (Vol.11[1], March 1965:5-26)
- M.C. Meigs (General),
"On the Conduct of the Civil War", American Historical Review (Vol.26[2], January 1921:285-303)
- R.K. Merton,
Science, Technology & Society in Seventeenth Century England (New Jersey, Humanities Press, 1978)
- E.G. Mesthene,
"General Implications of research of the Harvard University Programme on Technology & Society",
"Symposium: The Role of Technology in Society",
Technology & Culture (Vol.10, No.4, October 1969:489-504)
- W. Millis,
Armies & Men: A Study in American Military History (London, Jonathan Cape, 1958)
- K.L. Moll,
"A.T. Mahan, American Historian", Military Affairs (Vol.27[3], Fall 1963:131-140)
- J.G. Moore,
"Mobility & Strategy in the Civil War", Military Affairs (Vol. 24[2], Summer 1960:68-77)
- F. Myatt (Major),
The Illustrated Encyclopedia of Nineteenth Century Firearms (London, Tiger Books International, 1979)
- L. Naisawald,
Grape & Canister: The Story of the Field Artillery of the Army of the Potomac, 1861-1865 (New York, Oxford University Press, 1960)
- National Rifle Association of America,
Civil War Small Arms (An American Rifleman Reprint) (Washington, NRAA, 1960)

- A. Nevins,
Statesmanship of the Civil War (New York, Charles Scribners, 1953)
- A. Nevins,
The War for the Union (Vol.I) "The Improvised War 1861-62" (New York, Charles Scribners, 1959)
- A. Nevins,
The War for the Union (Vol.II) "The War becomes Revolution 1862-63" (New York, Charles Scribners, 1959)
- J.G. Nicolay & J. Hay,
"Abraham Lincoln: A History. The Call to Arms", The Century Magazine, (Vol.35[5], March 1888:707-723)
- J.G. Nicolay & J. Hay,
"Abraham Lincoln: A History. The Mississippi & Shiloh", The Century Magazine, (Vol.36[5], September 1888:658-678)
- D.C. North, T.L. Anderson, & P.J. Hill,
Growth & Welfare in the American Past: A New Economic History (Englewood Cliffs: New Jersey, Prentice Hall, 1983)
- P. O'Brien,
The Economic Effects of the American Civil War (London, MacMillan Education, 1988)
- Official Records,
"The War of the Rebellion, A Compilation of the Official Records of the Union & Confederate Armies" (70 Vol.-127 Books) (Washington D.C., Government Printing Office, 1880-1901)
- Official Naval Records,
"The Union & Confederate Navies in the War of the Rebellion" (31 Vol.- Including Index) (Washington D.C., Government Printing Office, 1894-1927)
- P.D. Olejar (Major),
"Rockets in Early American Wars", Military Affairs (Vol.10, 1946:16-34)
- On the Shelf: A Survey of Industrial R & D Projects Abandoned For Non-technical Reasons (London Centre for the Study of Industrial Innovation, July 1971)
- F.L. Owsley,
States Rights in the Confederacy (Chicago, Chicago University Press, 1925)
- P.J. Parish,
The American Civil War (London, Eyre Methuen, 1975)
- F.A. Parker (USN - Commodore),
The Battle of Mobile Bay (Boston, A. Williams, 1878)

- G. Parker,
The Military Revolution: Military Innovation & the Rise of the West, 1500-1800 (Cambridge, Cambridge University Press, 1988)
- R.S. Parker,
"Technology & Administration: A Summing Up", Public Administration (Vol. 22[1], March 1963:93-113)
- E. Taylor Parkes,
"Robert Fullerton & Submarine Warfare", Military Affairs (Vol.25[4], Winter 1961-62:177-182)
- R.J. Parkinson,
"United States Signal Corps Balloons", Military Affairs (Vol.24[4], Winter 1960-61:189-202)
- R.J. Parks,
Democracy's Railroads: Public Enterprise in Jacksonian Michigan (Port Washington, National University Publications, 1972)
- H. Pasha,
"Progress in Naval Armaments", North American Review (Vol.134[336], July 1884)
- L.M. Pearson,
"The Princeton & the Peacemaker: A Study in Nineteenth Century Naval Research and Development Procedures", Technology & Culture (Vol.7[2], Spring 1966:163-183)
- M. Pearton,
The Knowledgeable State: Diplomacy, War & Technology Since 1930 (London, Burnett Books, 1982)
- M.F. Perry,
Infernal Machines: The Story of Confederate Submarine & Mine Warfare (Baton Rouge, Louisiana State University Press, 1985)
- W.R. Plum,
The Military Telegraph: During the Civil War in the United States (Vol.I & II) (New York, Arno Press, 1974)
- G.I. Pokrovsky,
Science & Technology in Contemporary War (London, Atlantic Books, 1959)
- N. Polmar,
The American Submarine (London, Patrick Stevens, 1981)
- J.B. Poole,
"A Sword Undrawn: Chemical Warfare & the Victorian Age", (Part I) The Army Quarterly & Defence Journal (Vol. 106[4], October 1976:463-469)

- F.L. Pope,
"The American Inventors of the Telegraph", *The Century Magazine*, (Vol.35[6], April 1888:924-944)
- K Popper,
The Poverty of Historicism (London, Routledge & Kegan Paul, Second Edition 1961)
- K.A. Popper
The Logic of Scientific Discovery (London, Hutchinson, eighth impression, 1975)
- D.D. Porter,
"Naval Wars of the Future", *North American Review* (Vol.148[387], January 1889:196-216)
- D.D. Porter,
"The *Monitor* & The *Merrimac*", *North American Review* (Vol.148[388], February 1889)
- D.D. Porter,
The Naval History of the Civil War (New York, Castle, reprint 1984)
- E.B. Potter & C.W. Nimitz (eds),
Sea Power: A Naval History (Englewood Cliffs: New Jersey, Prentice-Hall, 1960)
- W.H. Powell,
"The Tragedy of the Crater", *The Century Magazine*, (Vol.34[3-62], July 1887:760-773)
- E.A. Pratt,
The Rise of Rail-Power: In War & Conquest, 1833-1914 (London, King & Son, 1915)
- T.J. Pressly,
Americans Interpret Their Civil War (Princeton, Princeton University Press, 1954)
- R.A. Preston,
"Military Lessons of the American Civil War", *Army Quarterly* (Vol.65, 1953:229-237)
- D.D. Price,
"Is Technology Historically Independent of Science? A Study in Statistical Historiography?", *Technology & Culture* (Vol.1, 1966:553-568)
- Purnells Illustrated Encyclopedia of Modern Weapons & Warfare* (9 Volumes) (London, Purnells, 1976)
- J.B. Rae,
"The 'Know-How' Tradition: Technology in American History", *Technology & Culture* (Vol.1[1], Summer 1959-1960:139-150)

- C.W. Ramsdell,
 "General Robert E Lee's Horse Supply, 1862-1865",
American Historical Review (Vol.35[4], July
 1930:758-777)
- C.W. Ramsdell,
 "The Changing Interpretation of the Civil War",
Journal of Southern History (Vol.3, February 1937:
 3-27)
- M.X. Raymond,
 "The English & French Navies", United Service
 Magazine & Naval & Military Journal (No.406,
 September 1862:40-50)
- R. Reed,
Combined Operations in the Civil War (Annapolis,
 Naval Institute Press, 1978)
- N. Reingold,
 "Science in the Civil War: The Permanent Commission
 of the Navy Department", ISIS (Vol.49[3], No.157,
 September 1958:307-318)
- C.G. Reynolds,
 "Yankee Supership? Sortie of Spuyten Duyvil",
American Neptune (Vol.42[2], 1982:85-100)
- H.G. Rickover (Vice-Admiral),
 "A Humanist Technology", Nature (Vol.208[5012],
 November 20, 1965:721-726)
- W. Ripley,
Artillery & Ammunition of the Civil War (New York,
 Van Nostrand Reinhold, 1970)
- E. Risch,
Quartermaster Support of the Army: A History of the
 Corps 1775-1939 (Washington DC, Quartermaster
 Historian's Office, Office of the Quartermaster
 General, 1962)
- G.I. Rochlin (ed),
Readings from Scientific American: Scientific
 Technology & Social Change (San Francisco, W.H.
 Freeman, 1974)
- J. Ronayne,
Science in Government (Victoria: Australia, Edward
 Arnold, 1984)
- H. Rose & S. Rose,
Science & Society (London, Pelican Books, 1970)
- W.S. Rosencrans,
 "The Campaign for Chattanooga", The Century
 Magazine, (Vol.34[19] April 1887:129-135)

- N. Rosenberg,
 "Technological Change in the Machine Tool Industry
 1840–1910", The Journal of Economic History
 (Vol.23[4], December 1963:414–443)
- N. Rosenberg (ed),
The American System of Manufacturers: The Report of
 the Committee on the Machinery of the United States
 1855 & the Special Reports of George Wallis & Joseph
 Whitworth 1854 (Edinburgh, Edinburgh University
 Press, 1969)
- N. Rosenberg (ed),
The Economics of Technological Change (London,
 Penguin, 1971)
- N. Rosenberg,
Technology and American Economic Growth (New York,
 Harper Torchbooks, 1972)
- I. Spiegel–Rosing & D. De Solla Price (eds),
Science, Technology & Society: A Cross–Disciplinary
 Perspective (London, Sage, 1977)
- R. Rothwell & W. Zegveld,
Industrial Innovation & Public Policy: Preparing for
 the 1980s & the 1990s (London, Francis Pinter, 1982)
- R. Routledge (ed),
Discoveries & Inventions of the Nineteenth Century
 (London, Bracken Books, 1989)
- S. Sandler,
 "A Navy in Decay: Some Strategic Technological
 Results of Disarmament 1865–1869 in the U.S. Navy",
Military Affairs (Vol.35[4], December 1971:138–141)
- J.E. Sawyer,
 "The Social Basis of the American System of
 Manufacturing", Journal of Economic History
 (Vol.14[4], 1954:361–379)
- Scientific American (Vol.12[4], January 21, 1865)
- L.M. Sears,
 "A Confederate Diplomat at the Court of Napoleon
 III", American Historical Review (Vol.26[2] January
 1921:255–281)
- J. Selby,
Stonewall Jackson: As Military Commander (London,
 Batsford, 1968)
- H. Schreiber,
 "Economic Change in the Civil War Era: An Analysis
 of Recent Studies", Civil War History (Part II,
 1965:396–411)

- F.A. Shannon,
The Organization & Administration of the Union Army
 (Vol.I & II) (Gloucester: Massachusetts, Peter
 Smith, 1965)
- W.T. Sherman (General, U.S. Army),
 "The Grand Strategy of the Rebellion" The Century
Magazine, (Vol.35[4], February 1888:582-598)
- Sherman
 "A Memorial in Art, Oratory & Literature By the
 Society of the Army of the Tennessee with the Aid of
 the United States of America", (58th Congress,
 Second Session 1903-1904, Senate Document No. 320)
 (Washington D.C., Government Printing Office, 1904)
- W.T. Sherman (General, U.S. Army),
Report of Major General William T Sherman (Report to
 the U.S. Congress, Joint Committee on the Conduct of
 the War 1863-1866) (New York, Kraus, Reprint 1977)
- B.B. Sideman (ed),
Europe Looks at the Civil War (New York, Onion
 Press, 1960)
- H.E. Simmons,
A Concise Encyclopaedia of the Civil War (New York,
 Barnes, 1965)
- I. Skennerton,
The British Sniper (London, Ken Trotman Arms Books,
 1984)
- C. Sleeman,
 "Development of the Machine Guns" North American
Review (Vol.139[336], July 1884)
- C.S. Smith,
 "The Interactions of Science & Practice in the
 History of Metallurgy", Technology & Culture
 (Vol.2[4], Fall 1961:357-367)
- J.D. Squires,
 "Aeronautics in the Civil War", American Historical
Review (Vol.13[4], July 1937)
- E.J. Stackpole,
 "Generalship in the Civil War", Military Affairs
 (Vol.24[2], Summer, 1960:57-67)
- W.N. Still,
Iron Afloat: The Story of the Confederate Ironclads
 (Nashville, Vanderbilt University Press, 1971)
- V.D. Stockbridge,
Digest of Patents Relating to Breech-loading &
Magazine Small Arms (Except Revolvers), Granted in
the United States from 1836-1873, Inclusive
 (Washington DC, U.S. Patents Office, 1874)

- C. Levis-Strauss,
"Race & History" in L. Kuper (ed), *Race, Science & Society* (London, Allen & Unwin, 1975:95-134)
- H. Stretton,
The Political Sciences: General Principles of Selection in Social Sciences & History (London, Routledge, & Kegan Paul, 1972)
- F. Suppe (ed),
The Structure of Scientific Theories (Urbana, University of Illinois, 1974)
- G.R. Taylor,
The Transportation Revolution, 1815-1860 (Economic History of the United States Vol.4) (New York, Harper Torchbooks, 1951)
- G.R. Taylor & I.D. Neu,
The American Railroad Network 1861-1890 (Cambridge: Massachusetts, Harvard University Press, 1956)
- G.R. Thompson,
"Civil War Signals", *Military Affairs* (Vol.28[4], Winter 1954:188-201)
- G.E. Turner,
Victory Rode the Rails: The Strategic Place of the Railroads in the Civil War (Westport: Connecticut, Greenwood Press, 1972)
- L.C.F. Turner,
"The Grand Strategy of the Civil War", *Australian Journal of Politics & History* (Vol.26[1] 1980:57-70)
- H.W. Tyler,
"Strategy Considered", *Journal of Royal United Service Institute* (Vol.8, June 1864)
- United Service Magazine, Naval & Military Journal,
"Defects of Armour Plating" (Part I, No.399, February 1862)
- United Service Magazine, Naval & Military Journal,
"The American War" (Part I, No.400, March 1862)
- United Service Magazine, Naval & Military Journal,
"Merrimac Conversion" (Part I, No.402, March 1862)
- United Service Magazine, Naval & Military Journal,
"Steam Ships & Steam Officers" (Part I, No.401, April 1862)
- United Service Magazine, Naval & Military Journal,
"Continental Armies & Foreign Politics" (Part I, No.406, September 1862:1-21)

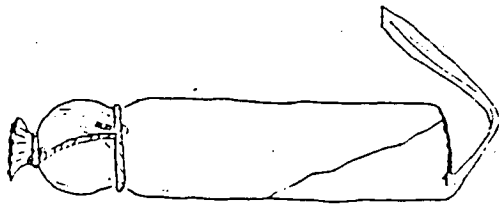
- United Service Magazine, Naval & Military Journal,
"New Guns Versus Old Fortifications" (Part I,
No.407, October 1862:198-208)
- United Service Magazine, Naval & Military Journal,
"Ordnance Versus Iron Plate" (Part I, No.407,
October 1862:289-90)
- United States - Military Railroads Department,
U.S. Military Railroads: Report of Brevet Brigadier
General D.C. McCallum Director & General Manager
From 1861 to 1866 (Washington, US Army, 1866)
- B.E. Upton,
Infantry Tactics Double and Single Rank - Adapted to
American Topography & Improved Firearms (New York,
Greenwood Press, 1968 - Reprint of 1874)
- P.J. Useling,
"Henry Burden & the Question of Anglo-American
Technological Transfer in the Nineteenth Century",
Journal of Economic History (Vol.30[2], June
1970:312-337)
- R.F. Wacht,
"A Note on the Cochran Thesis & the Small Arms
Industry in the Civil War", Explorations in
Entrepreneurial History (Vol.4[1], 1966:57-62)
- R.F. Weigley,
The American Way of War: A History of United States
Military Strategy & Policy (New York, MacMillan,
1973)
- B.A. Weisberger,
The New Industrial Society (New York, John Wiley,
1969)
- H.C. Westwood,
"Benjamin Butler's Naval Brigade", Civil War History
(Vol.34[3], September 1988:253-270)
- R. Wheeler,
We Knew William Tecumesh Sherman (New York,
Thomas Y Cromwell, 1977)
- B.T. White,
Tanks & Other Armoured Fighting Vehicles 1900
to 1918 (London, Blandford Press, 1970)
- L. White (Jnr),
Medieval Technology & Social Change (London, Oxford
University Press, 1980)
- W. Whitman,
"Army Hospital & Cases", The Century Magazine,
(Vol.36[6], October 1888:825-830)

- F. Wilkinson,
The World's Great Guns (London, Hamlyn, 1977)
- R.A. Williams,
"Enter the Breech-Loader", Military Review
(Vol.45[4], April 1965:60-64)
- N. Willmott & J. Pimlott,
Strategy & Tactics of War: Land, Sea & Air (London,
Marshall Cavendish, 1979)
- Wolseley (Viscount),
"An English View of the Civil War", North American Review,

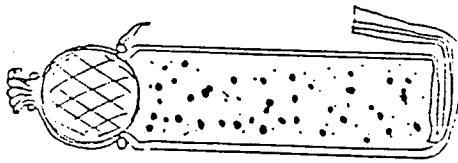
(Part I) (Vol.148[390], January 1889:538-563)
(Part II) (Vol.149[392], July 1889:30-43)
(Part III) (Vol.149[393], August 1889:164-181)
(Part IV) (Vol.149[394], September 1889:278-292)
(Part V) (Vol.149[395], October 1889:446-459)
(Part VI) (Vol.149[396], November 1889:594-606)
(Part VII) (Vol.149[397], December 1889:715-727)
- R.S. Woodbury,
"The Legend of Eli Whitney & Interchangeable Parts",
Technology & Culture (Vol.1[1], Summer 1959
-1960:235-253)
- T. Yoseloff (ed),
Confederate Military History (12 Vols.) (New York,
Thomas Yoseloff, 1962)
- D.W. Ziegler,
War, Peace & International Politics (Boston, Little
Brown, Fourth Edition 1987)
- S. Zuckerman,
Scientists & War: The Impact of Science on Military
& Civil Affairs (London, Scientific Book Club, 1966)
- A. Zvorikine,
"The History of Technology as a Science & As a
Branch of Learning: A Soviet View", Technology &
Culture (Vol.2[1], Winter 1961:1-4)

APPENDICES

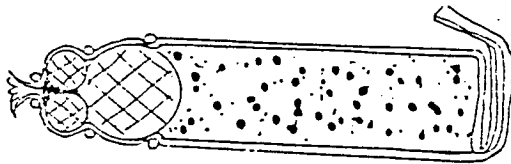
EARLY PAPER CARTRIDGES



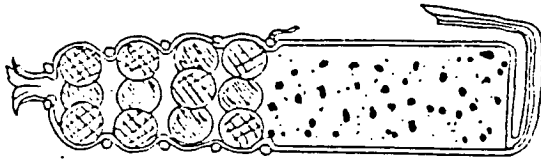
Paper Wrapped Nuzzle-Lading Cartridge



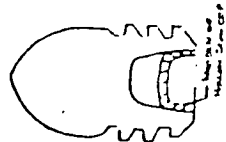
0.69 Cal. Nuzzle-Lading Cartridge



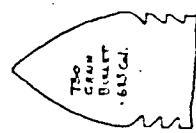
0.69 Cal. Ball & Three Buckshot



0.58 Cal. Buckshot Cartridge (12 Balls)



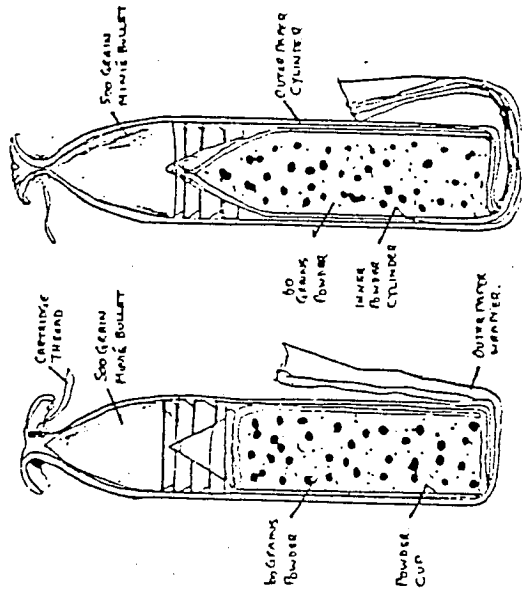
Early Minie



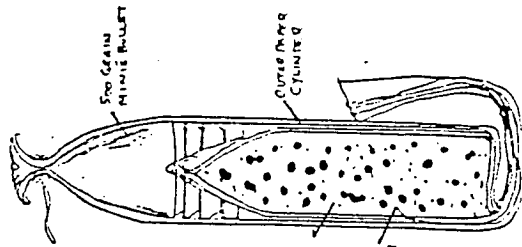
M 1856 Minie M 1856 Minie 0.69 Cal.



0.58 Cal.

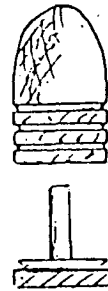


0.58 Cal. M 1856 Cartridge Design

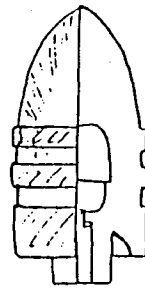


0.58 Cal. M 1861 Cartridge Design

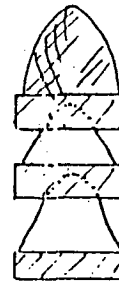
EARLY BULLETS AND PAPER CARTRIDGES



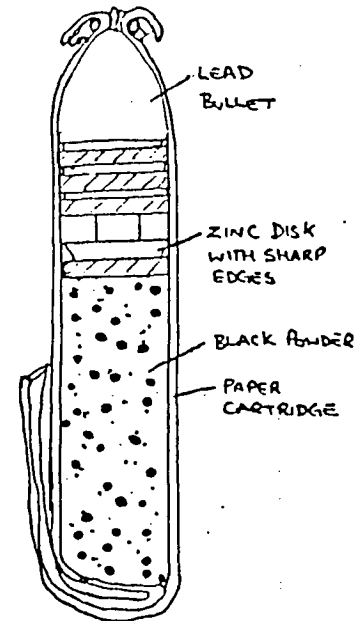
Williams Patent
Bullet



Gardiner Bullet

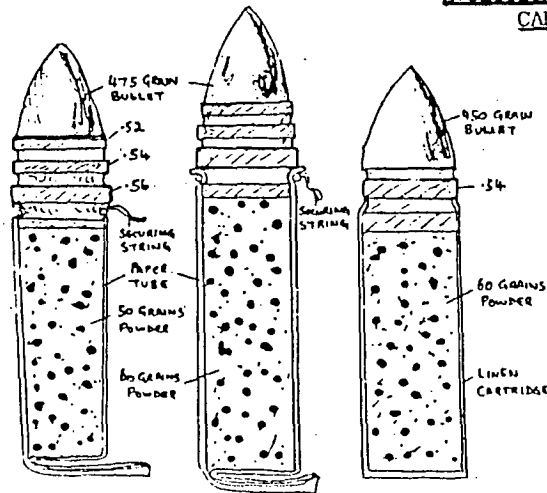


0.58 Cal. Shaler
Sectional Bullet



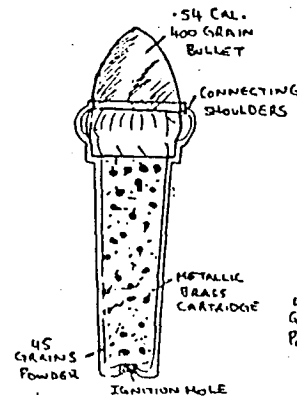
0.58 Cal. Williams
Bullet With Paper
Cartridge

EVOLUTION OF CIVIL WAR SELF CONTAINED SOLID
CARTRIDGE AMMUNITION

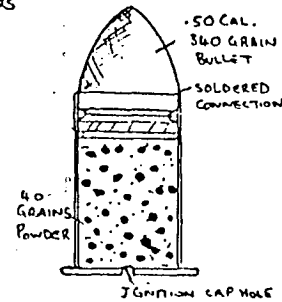


0.56 Cal. Sharps Cartridge for Carbines 0.52 Cal. Sharps Cartridge for Carbines

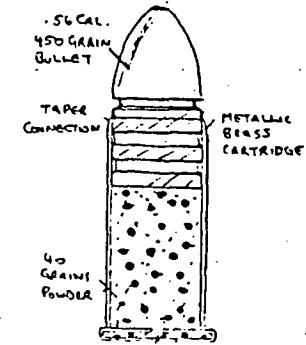
0.56 Cal. Sharps Cartridge for Rifles



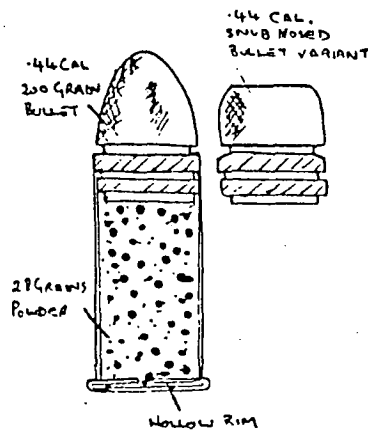
M 1860 Burnside Carbine Cartridge



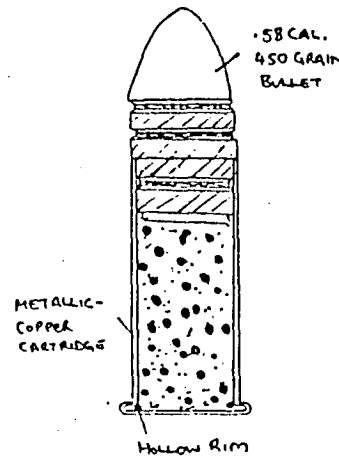
M 1860 Maynard Carbine Cartridge



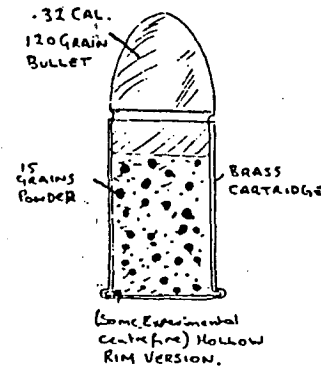
M 1864 Spencer Rim-Fire Carbine Cartridge



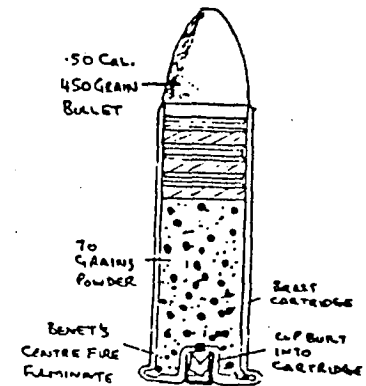
M 1864 Henry Rim Primed Repeating Rifle Cartridge



M 1864 Gatling Rim-Fire Machine Gun Cartridge



M 1864-1865 Smith & Wesson Revolver Cartridge



M 1865-1866 Experimental Frankford Arsenal (Berdam) Cartridge

UNION CARBINES

Carbines Purchased By US Ordnance Bureau 1861-1865	Caliber	Total Number Purchased	Total Cost \$US 1865	Total No. Of Rounds Purchased	Total Cost Of Rounds \$US 1865	Date Of Carbines Patent	Date Of Carbines Official Adoption
Ballard	0.44/0.54	1,509	35,140	3,527,450	57,945	5 Nov. 1861	1862
Ball	0.44/0.50	1,002	25,387	See Spencer	See Spencer	1864	May 1865
Burnside	0.54	55,567	1,412,620	11,819,200	547,490	25 Mar. 1865	1861
Gwyn & Campbell or Cosmopolitan	0.50	9,342	199,838	6,300,000	132,007	21 Oct. 1862	1863
Gallager	0.51	22,728	508,492	8,294,023	211,093	17 Jul. 1860	1862
Gibbs	0.52	1,052	27,995	-	-	8 Jan. 1856	1863
Hall	0.52/0.64	3,520	64,762	-	-	30 Jul. 1844	1861
Joslyn-Percussion -Carbine	0.54	860	282,568	515,416	12,935	28 Aug. 1855	1861/1863/
	0.54	11,261				8 Oct. 1861	1864 & 1865
Lindner	0.57	892	19,895	100,000	2,262	-	-
Maynard	0.50	20,002	489,399	2,157,000	72,207	6 Dec. 1859	1861
Merrill	0.54	14,495	374,804	5,509,750	105,779	20 Jul. 1858	1861-1862
Palmer	0.44/0.50	1,001	20,918	See Spencer	See Spencer	1863	1865
				& Henry	& Henry		
Remington	0.46	20,000	436,752	4,257,000	68,600	15 Nov. 1864	1864/1865
Sharps	0.52	80,517	2,213,192	16,306,508	347,410	1848/52 & 64	1859
				Sharps & 1,001,000	27,402	1862/63 & 64	1862
				Hankins			
Smith	0.50	30,062	745,645	13,861,500	377,569	5 Aug. 1856 & 23 Jun. 1857	1862-63
Spencer	0.52	94,196	2,393,633	58,238,924	1,419,277	6 Mar. 1860 & 20 Jul. 1862	1862-1863
Starr	0.54	25,603	586,773	6,860,000	140,768	14 Sep. 1858	1861
Warner	0.50	4,001	79,310	1,828,000	27,472	23 Sep. 1864	Mar. 1865
Wesson	0.44	151	3,491	254,000	3,666	1864	1865
OTHERS							
French Carbines	0.60	200	4800				
Foreign Carbines	Various	10051	66193	From Stock			
Musketoons	0.54, 0.64 & 0.69	587	5815	From Stock & 0.54 Hall's Paper Round		Original Patent	1842 (1848 to 1852 Converted)

RIFLES & MUSKETS PURCHASED
BY THE US ORDNANCE BUREAU
1861-1865

Rifles & Muskets Purchased By US Ordnance Bureau 1861-1865	Caliber	Total Number Purchased	Total Cost \$US 1865
SPRINGFIELD RIFLE-MUSKET*	0.58	670,617	13,089,855
LINDSAY DOUBLE SHOT MUSKET	0.58	1,000	25,250
BALLARD RIFLE	0.54	35	1,262
COLT REVOLVING RIFLE	0.44/0.56	4,612	204,487
GREENE RIFLE	0.54	900	33,266
HENRY RIFLE	0.44	1,731	63,953
MERRILL RIFLE	0.54	583	23,880
SHARPS RIFLE	0.52	9,141	330,629
SPENCER RIFLE	0.52/0.56	12,471	467,390
HALL RIFLE	0.52	1,575	23,704
HARPER FERRY RIFLE	0.54/0.58	22,793	414,316
RIFLES 0.69 CALIBER	0.69	1,832	20,076
AMERICAN SMOOTH-BORE MUSKETS	0.69	2,181	21,825
Foreign Rifles			
ENFIELD LONG & SHORT RIFLES	0.577	428,292	7,869,175
BOKER RIFLE	0.71	162,533	2,267,834
BOKER (WITH SWORD BAYONET)	0.70	25,000	139,254
FRENCH RIFLES	0.71	44,250	757,416
BELGIUM RIFLES	0.69/0.71	57,467	811,109
AUSTRIAN RIFLES	0.72	226,294	2,640,704
PRUSSIAN RIFLES	0.69-0.71	59,918	590,485
JAGER RIFLES	0.54	29,850	260,785
SUHL RIFLES	0.71	1,673	26,056
TOWER RIFLES	0.71	4,182	18,819
GARIBALDI	0.69/0.71	5,995	35,970
PRUSSIAN SMOOTH-BORE MUSKETS	0.69-0.71	81,652	554,849
FOREIGN SMOOTH-BORE MUSKETS	Various	29,201	234,345
RIFLES OF VARIOUS KINDS	Various	641	15,256
TOTAL		1,894,453	30,941,950

* Not including the 800,000 manufactured in Federal armories

**PERFORMANCE OF CIVIL WAR
SHOULDER FIRE ARMS**

TYPE OF WEAPON	CALIBRE (Inches)	(1) TYPE OF ACTION	(2) 50 YARD ACCURACY (Inches)	MAXIMUM EFFECTIVE RANGE (Yrds)
M1855 SPRINGFIELD RIFLE-MUSKET	0.581	RML	5.25	300
M1863 SPRINGFIELD	0.58	RML	5.25	350-400
M1842 RIFLED MUSKET	0.694	RML	7.25	200
M1819 HALL FLINTLOCK RIFLE	0.535	RBL	7.25	80-130
M1863 NEW MODEL SHARPS RIFLE	0.52	RBL	5.25	350-400
LONG ENFIELD RIFLED MUSKET	0.577	RML	3.75	450
AUSTRIAN RIFLE	0.546	RML	6	250
M1842 TOWER PERCUSSION MUSKET	0.725	SHL	8.5	80
BELGIUM PERCUSSION MUSKET	0.68	SHL	13	50
FRENCH TIGE RIFLE	0.79	RBL	8.5	120
WHITWORTH	0.452	HEX-ML	1-2	1000-1200
SPENCER	0.56	RBL		600

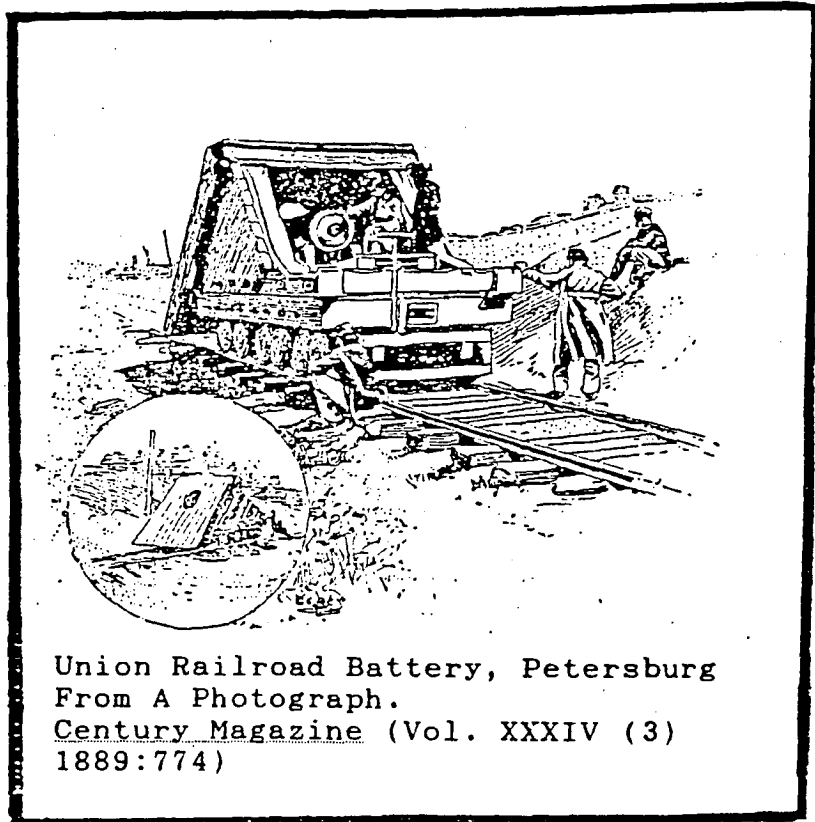
(1) RML=Rifled Muzzle Loader, RBL= Rifled Breech Loader,
SHL=Smooth Bore Muzzle Loader, & Hex-ML=Hexagonal Muzzle Loader
(2) Accuracy = Grouping of five shots
(See NRAA, Civil War Small Arms 1960:26)

REVOLVERS & PISTOLS PURCHASED
BY THE US ORDNANCE BUREAU
1861-1865

Revolvers & Pistols Purchased By US Ordnance Bureau 1861-1865	Caliber	Total Number Purchased	Total Cost \$US 1865
ALLEN & WHEELOCK	0.44	536	9,130
ADAMS	0.44	415	7,526
BEALS	0.36/0.44	2,814	38,315
COLT ARMY	0.44	129,730	2,296,112
COLT NAVY	0.37	17,010	466,068
JOSLYN	0.44	1,100	24,793
PERRIN	0.44	200	4,000
PETTINGILL	0.44	2,001	40,287
LEFAUCHEUX ARMY	0.43	52	
LEFAUCHEUX NAVY	0.35	11,781	167,489
REMINGTON ARMY	0.44	125,314	1,631,629
REMINGTON NAVY	0.36	4,901	59,838
RAFAEL	0.41	978	16,181
SAVAGE NAVY	0.36	11,284	221,355
STARR	0.36/0.44	47,952	737,793
ROGER & SPENCER	0.44	5,000	60,739
WHITNEY NAVY	0.36	11,214	139,690
FOREIGN PISTOLS	Various	100	1,000
HORSE PISTOLS	Various	200	1,400
SIGNAL PISTOLS		348	1,935
COLT POCKET	0.31	17,010	
SMITH & WESSON	0.22/0.32		
SMITH & WESSON "VOLCANIC REPEATING PISTOL"	0.31/0.38		
LA MAT (French)	0.44 & 0.65		
TOTAL		389,940	5,925,280

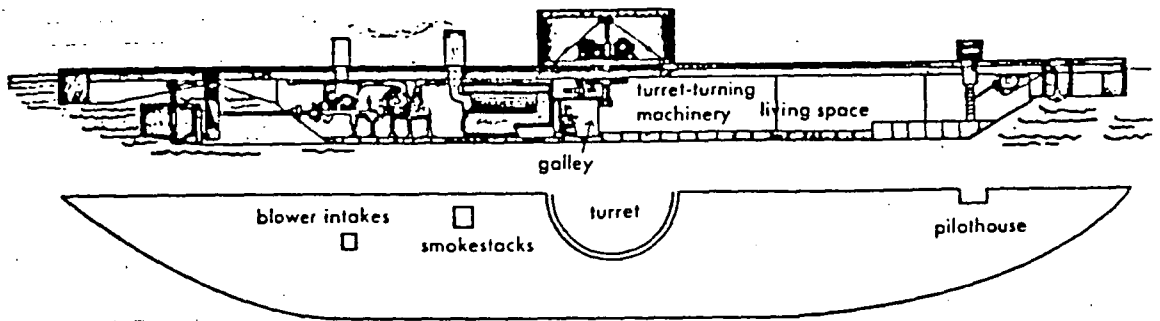
**REVOLVERS & PISTOLS IN SERVICE
WITH THE CONFEDERATE ARMY
1861-1865**

Revolvers & Pistols In Service With The Confederate Army 1861-1865	Caliber
M1807 VIRGINIA	0.70
PALMETTO M1842	0.54
RAPPAHANNOCK FORGE FLINTLOCK	0.65
MOCK ENGLISH FLINTLOCK	(0.65?)
COLT ARMY	0.44
REMINGTON ARMY	0.44
WHITNEY	0.36
ENGLISH KERR	0.44
ENGLISH DEANE	0.44
ENGLISH TRANTER	0.36
FRENCH LA MAT	0.42 & 0.50
FRENCH PIN FIRE	0.45
M1851 COLT NAVY	0.36
DIMICK "COLT"	0.36
SMITH & WESSON	0.32
M1842 RICHMOND	0.54
SHANK & McLANAHAN	0.36
CUFER CONFEDERATE REVOLVER	0.36
LEECH & RIGDON	0.36
RIGDON & ANSLEY	0.36
COLUMBUS FIRE-ARMS	0.36
SAMUEL SUTHERLAND	0.45
TUCKER & SHERROD	0.44
DANCE & PARK	0.44
DANCE & PARK NAVAL	0.36



Union Railroad Battery, Petersburg
From A Photograph.

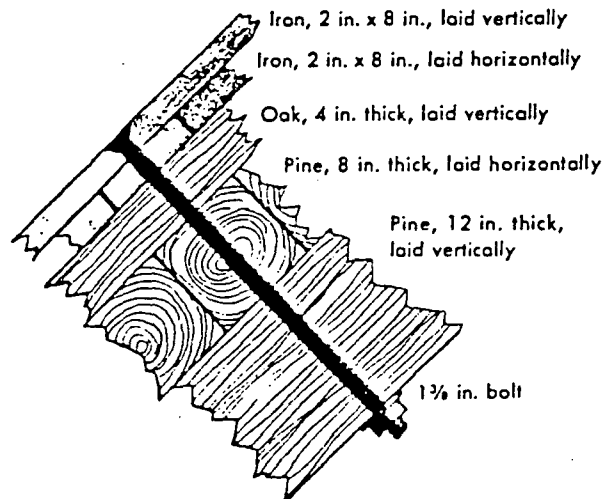
Century Magazine (Vol. XXXIV (3)
1889:774)



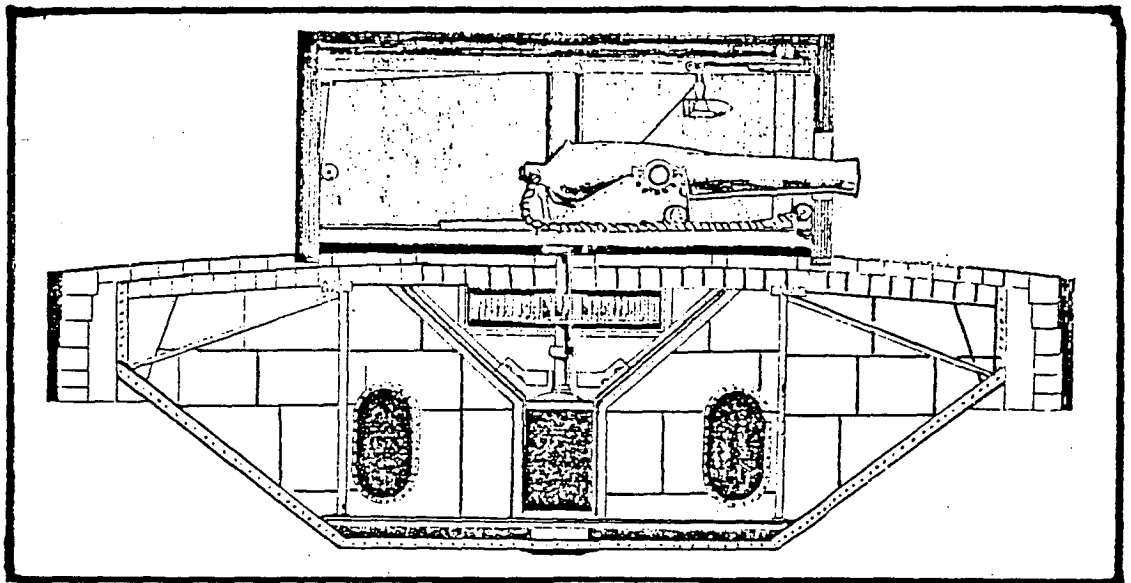
USS MONITOR AND DETAILS OF ARMoured SHIELD

- Hull:** length- 172 feet; beam- 41 feet 6 inches; draft- 11 feet; freeboard- 1 foot
- Turret:** 20 feet (inside diameter); height- 9 feet; thickness- 8 inches (8 layers of one inch wrought-iron plates bolted together); revolved on central spindle small steam engine; turret top- heavy iron grating, with sliding hatches.
- Armament:** two 11-inch smoothbores firing solid shot weighing 180-pounds.
- Engine:** single, horizontal, driving one four-bladed propeller nine feet in diameter; speed- five knots; two return tube boilers, forced draft by blowers; two rectangular smokestacks six feet high; two blower pipes, four and a half feet high (stacks and blower intake pipes taken apart and laid flat when cleared for action).

Coggins (1962:135)



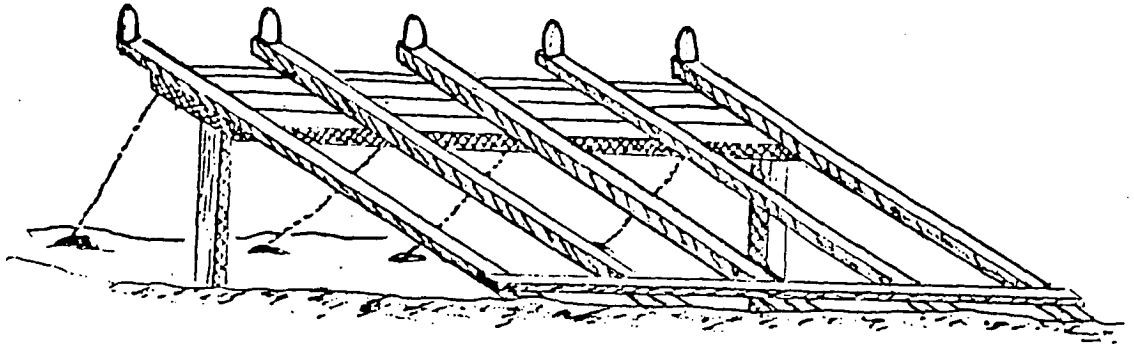
Coggins (1962:134)



A SECTION THROUGH THE USS MONITOR SHOWING ITS TURRET AND 11-INCH DAHLGREN GUNS (I. Hogg, Artillery 118).

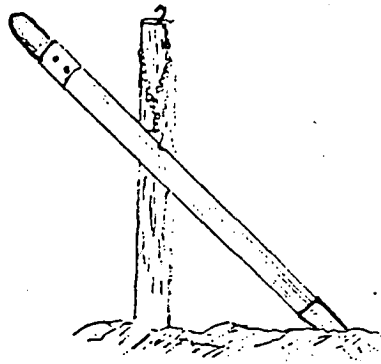
Hogg & Batchelor, (1974:118)

TORPEDOES

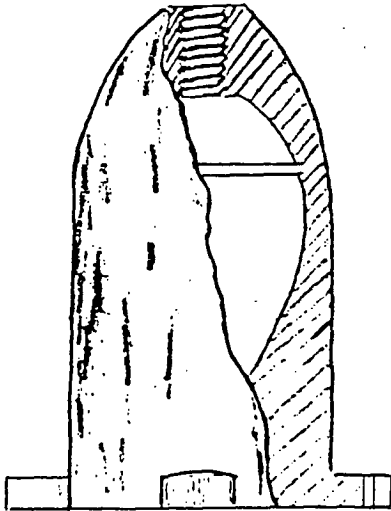


Rebel Frame Torpedo

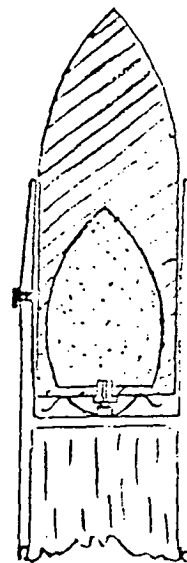
Obstruction torpedo



Barnes, (1869:plate 4.1)

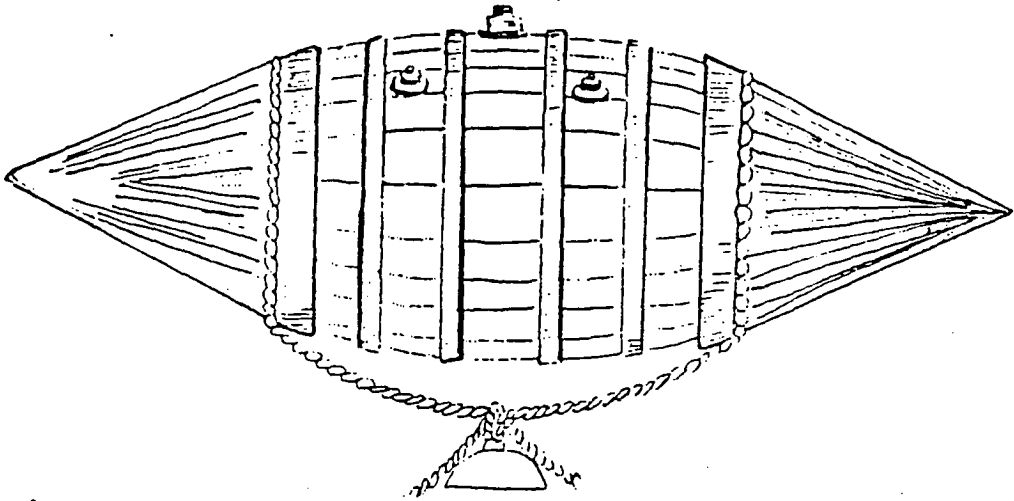


Frame Torpedo & Land
Obstruction Torpedo
(Cast iron shell with
percussion detonator)
Barnes, (1869:plate 4.4)

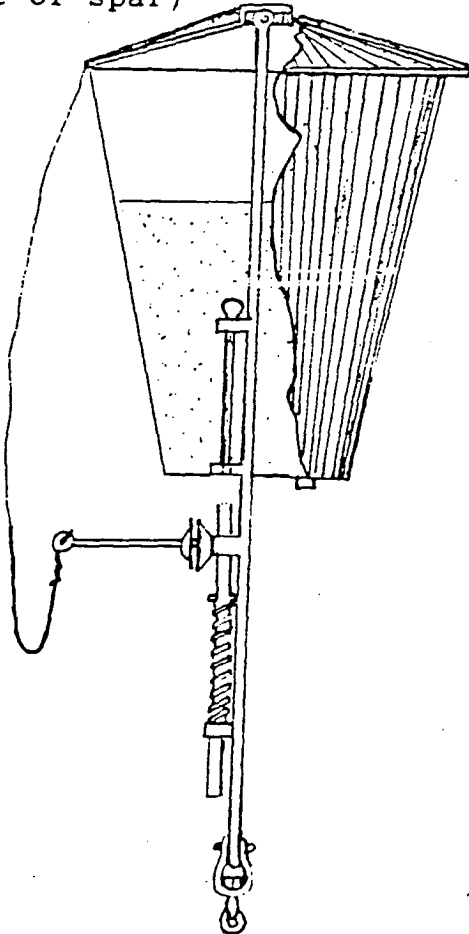


Obstruction Torpedo
(Percussion/presure forces
spring to contact points
to meet & detonate cast iron
shell. Timber housing, cast
iron shoe embedded into seabed)
Barnes, (1869:plate 4.3)

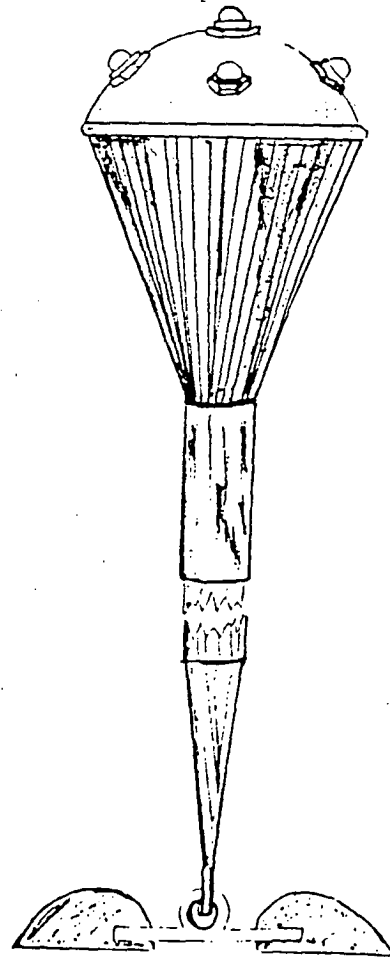
Floating Boyant Keg Torpedo
(100 lb powder chemical or
percussion fuse)



Singer Torpedo
(Air in top of frame, powder in bottom,
cast iron sled, trigger, firer connection
to side of spar)



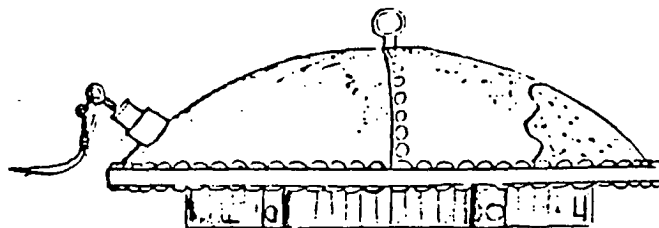
Brooke Boyant Torpedo
(Chemical sensitive fuse, cast iron
frame, wooden spar and mud anchors)



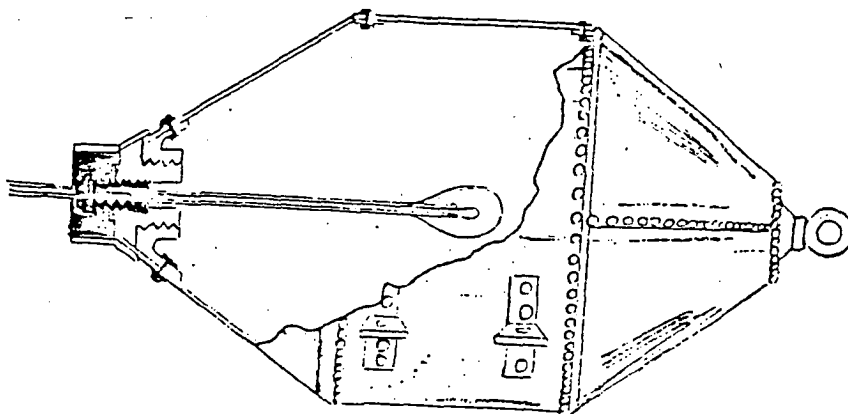
Keg Torpedo in Barnes, (1869:plate 6.1)

Brooke Torpedo in Barnes, (1869:plate 6.3)

Singer Torpedo in Barnes, (1869:plate 6.2)

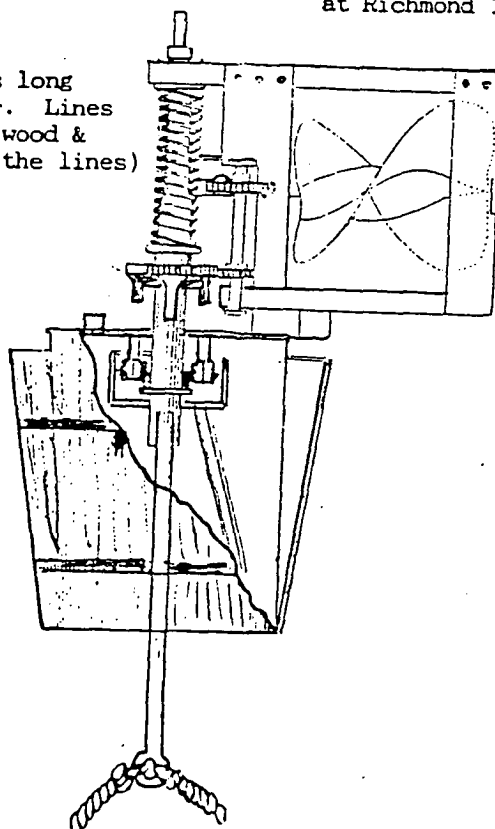


"Devil Circumventor"
 (Set into ground & fired by electrical
 wire or lanyard & pin)
 (Called "Turtle" and used in 100 lb
 powder load at Richmond & Charleston)



CSN Electrically Fired Torpedo
 (Fired by an observer - Used successfull
 at Richmond 1865)

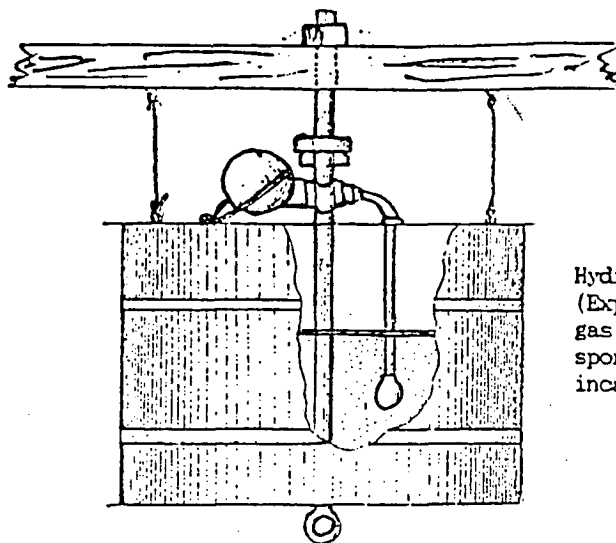
Mobile Floating Mine
 (Tin cylinder 16.5 inches long
 & 11.5 inches in diameter. Lines
 were attached to floating wood &
 exploded on contact with the lines)



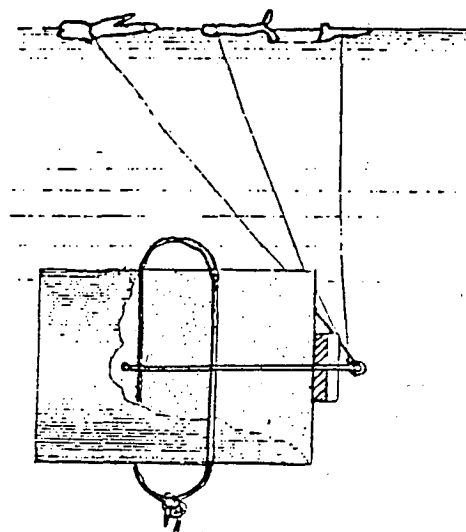
Devil Torpedo in Barnes, (1869:plate 7.1)

Electric Torpedo in Barnes, (1869:plate 9.1)

Mobile Floating Torpedo in Barnes, (1869:plate 7.4)

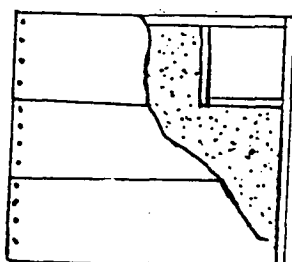


Hydrogen Gas Torpedo
(Exploded by jet of Hydrogen
gas shot into small mass of
spongy platinum so becoming
incandescent & igniting)

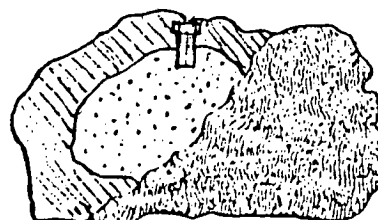


Drift Mine

Clockwork Torpedo
(Time bomb)



Coal Torpedo
(Air hole, solid cast iron shell,
powder filled)



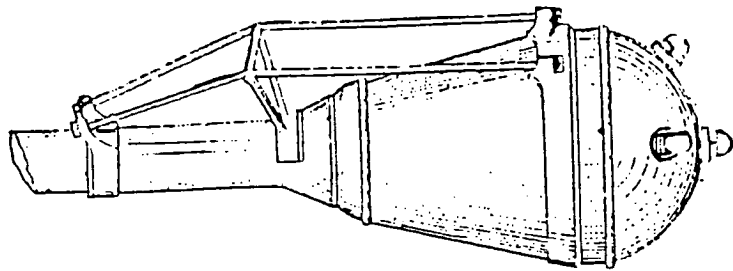
Hydrogen Torpedo in Barnes, (1869:plate 8.1)

Drift Torpedo in Barnes, (1869:plate 8.2)

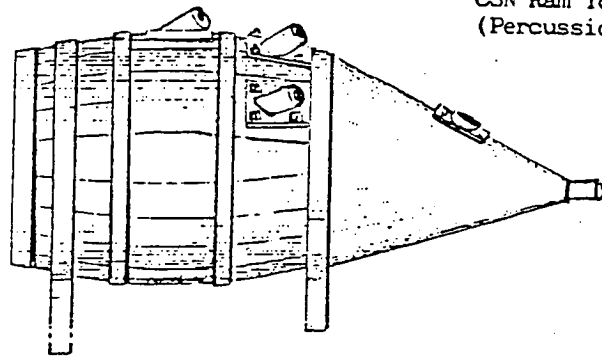
Coal Torpedo in Barnes, (1869:plate 8.5)

Clockwork Torpedo in Barnes, (1869:plate 8.4)

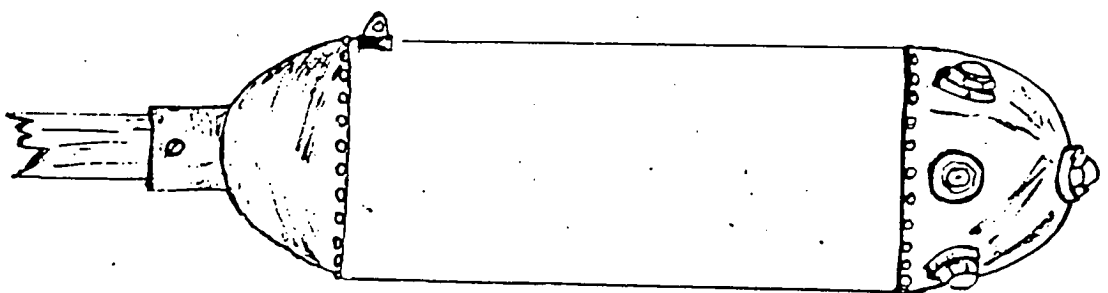
CSN Ram Torpedo
(Chemical sensitive fuse)



CSN Ram Torpedo
(Percussion fuses)



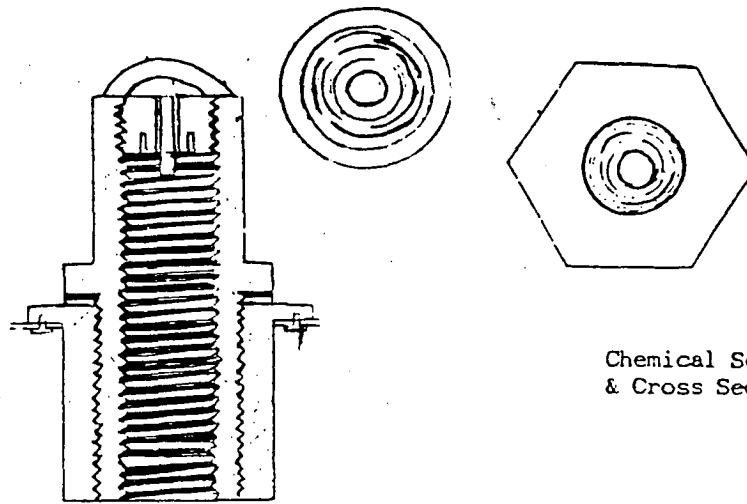
David Spar Torpedo



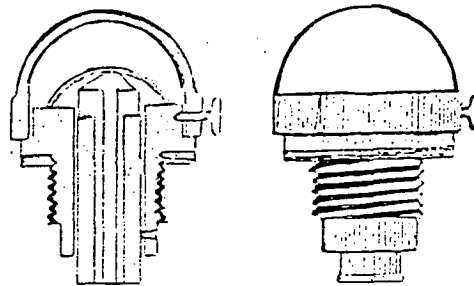
Chemical Ram Torpedo in Barnes, (1869:plate 9.1)

Percussion Ram Torpedo in Barnes, (1869:plate 9.2)

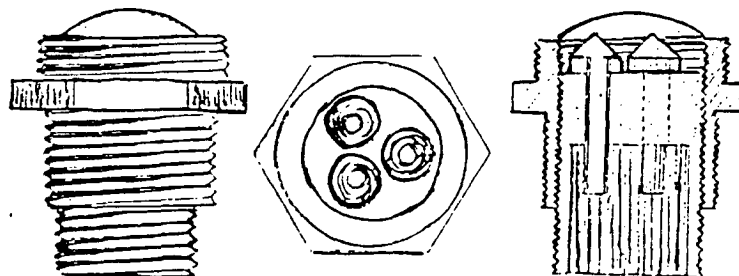
David Spar Torpedo in Barnes, (1869:plate 9.4)



Chemical Sensitive Fuse
& Cross Section



Ground Fuse
& Cross Section



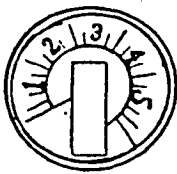
Composition Metal Percussion
Primer & Cross Section

Barnes, (1869:plate 5.3)

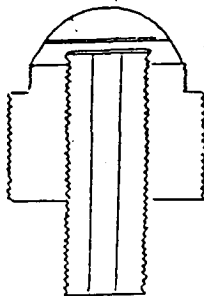
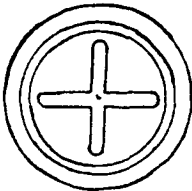
Barnes, (1869:plate 5.4)

Barnes, (1869:plate 5.5)

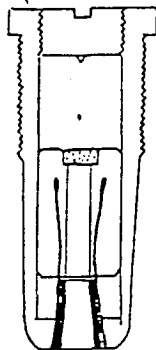
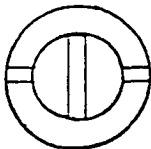
FUSES - CROSSECTIONS



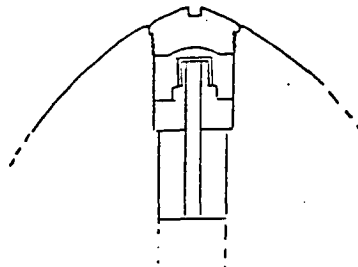
Bormann Time
Hackley, (1960:31)



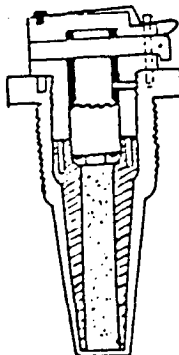
Confederate Land Mine
Hackley, (1960:32)



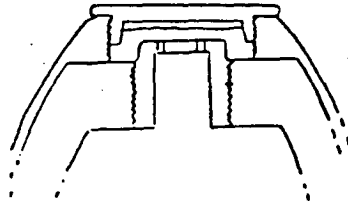
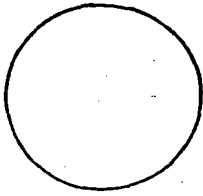
US Hotchkiss Percussion
Hackley, (1960:33)



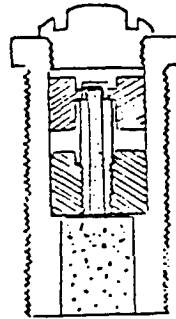
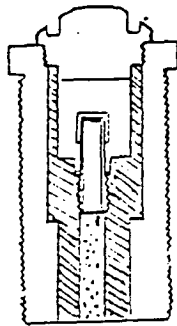
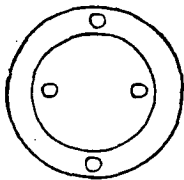
US James Percussion
Hackley, (1960:34)



US Schenkl Combination
Hackley, (1960:40)

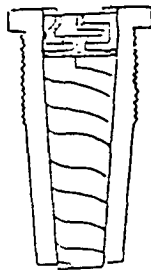
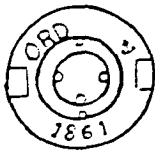


US Sawyer Percussion
Hackley, (1960:39)

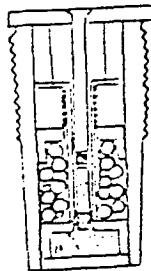


US Parrott Percussion
First Type
Hackley, (1960:37)

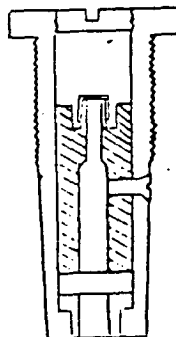
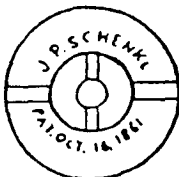
US Parrott Percussion
Second Type
Hackley, (1960:38)



US Water Captive
Hackley, (1960:44)



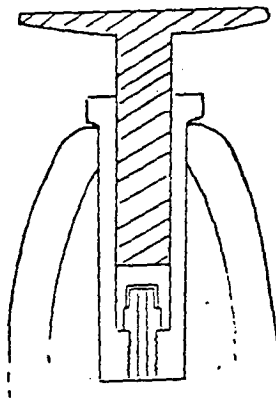
US Tice Concussion
Hackley, (1960:42)



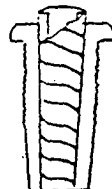
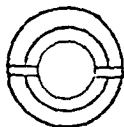
US Schenkl Percussion
Hackley, (1960:41)



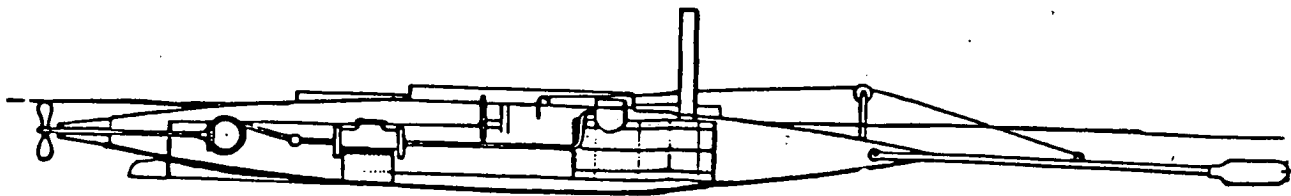
Mortar Time Fuse
Hackley, (1960:36)



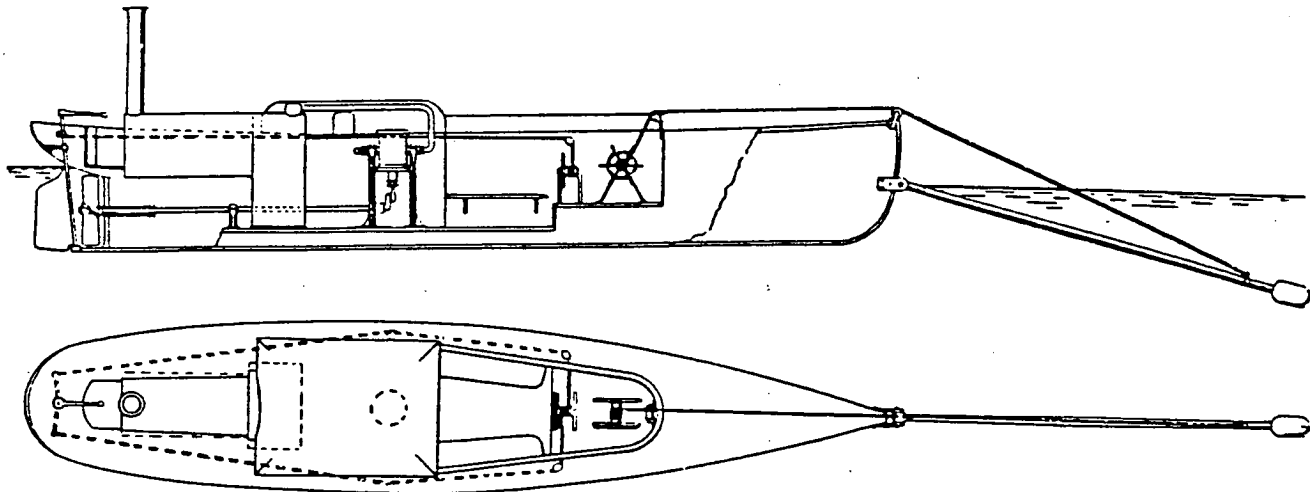
US Ketcham Grenade
Hackley, (1960:35)



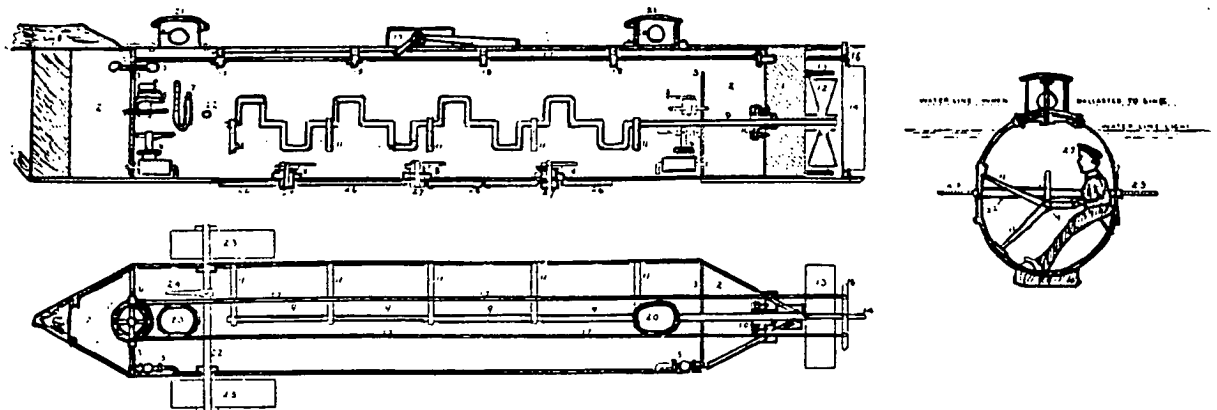
Time Fuse
Hackley, (1960:43)



David in McBride, (1962:108-109)



Squib in Civil War Naval Chronology 1861 - 1865 (Parts IV, Undated:38)



From sketches by W. A. Alexander.

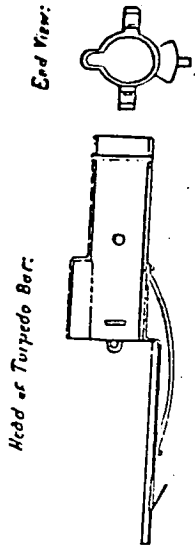
CONFEDERATE STATES SUBMARINE TORPEDO BOAT H. L. HUNLEY. LONGITUDINAL ELEVATION, PLAN, AND TRANSVERSE SECTIONAL VIEWS.

1. The bow and stern castings; 2, water-ballast tanks; 3, bulk bulkheads; 4, compass; 5, sea cocks; 6, pumps; 7, mercury gauge; 8, keel ballast stuffing boxes; 9, propeller shaft and crank; 10, stern bearing and gland; 11, shaft braces; 12, propeller; 13, wrought ring around propeller; 14, rudder; 15, steering wheel; 16, steering lever; 17, steering rods; 18, rod braces; 19, air box; 20, hatchways; 21, hatch covers; 22, shaft of side fins; 23, side fins; 24, shaft lever; 25, one of the crew turning propeller shaft; 26, cast iron keel ballast; 27, bolts; 28, butt end of torpedo boom.

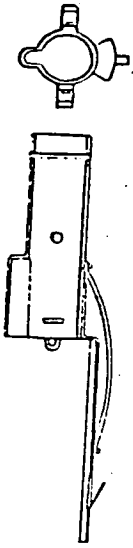
Confederate Submarine Torpedo Boat H.L. Hunley
Official Naval Records (Series 1, Vol.15, 1902:338)

SCREW PICKET BOAT

Constructed for the Navy Department.



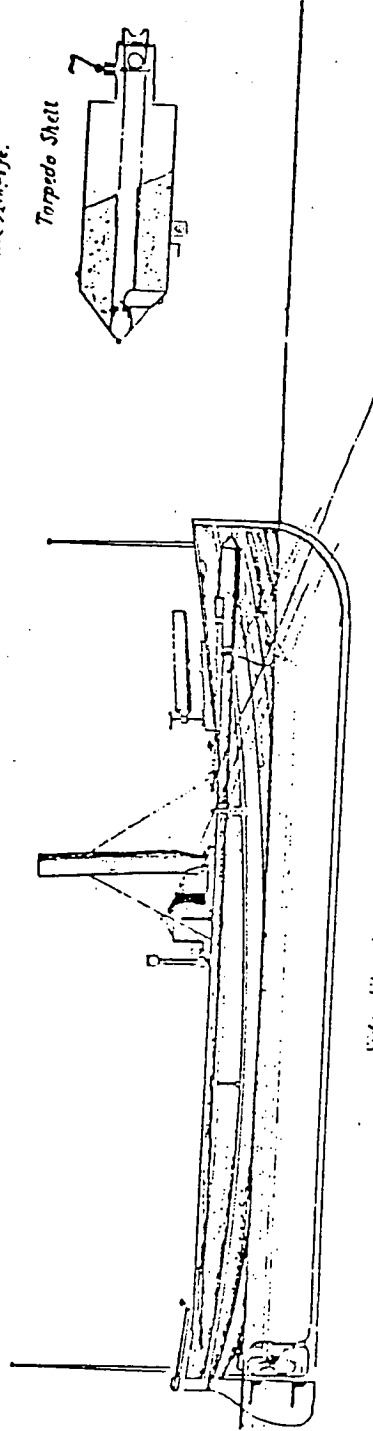
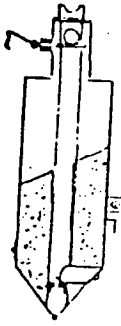
End View:



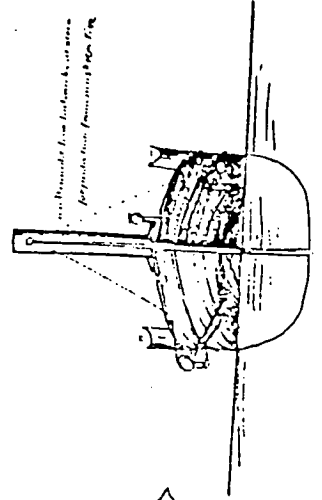
Scale 1/2 in. = 1 ft.

Scale 1/2 in. = 1 ft.

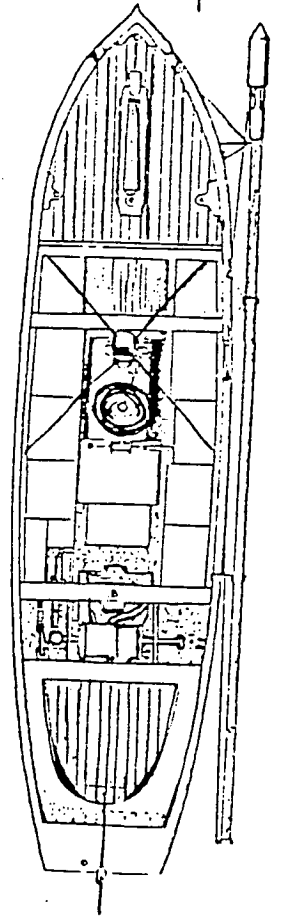
Torpedo Shell



Side Elevation

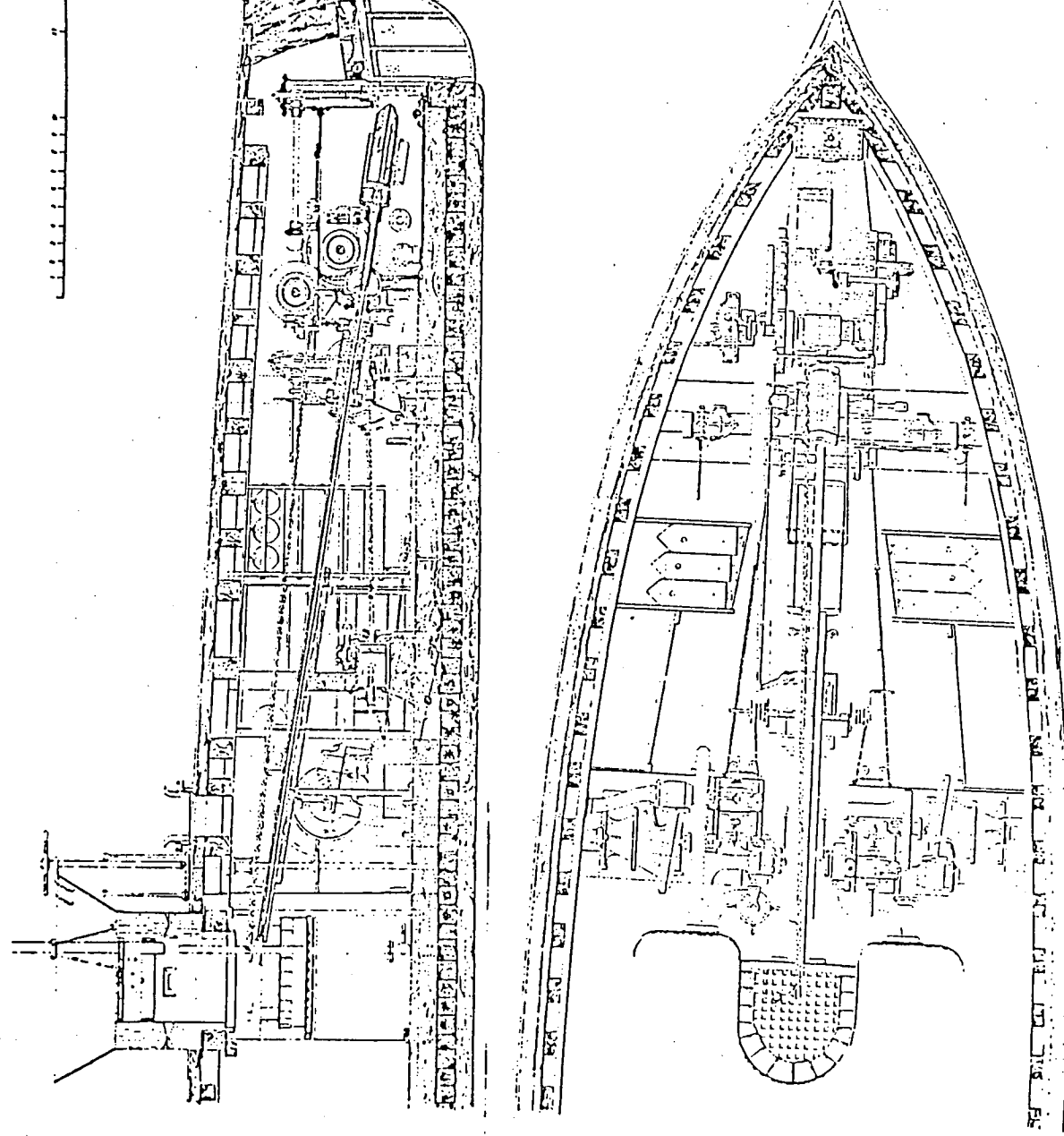


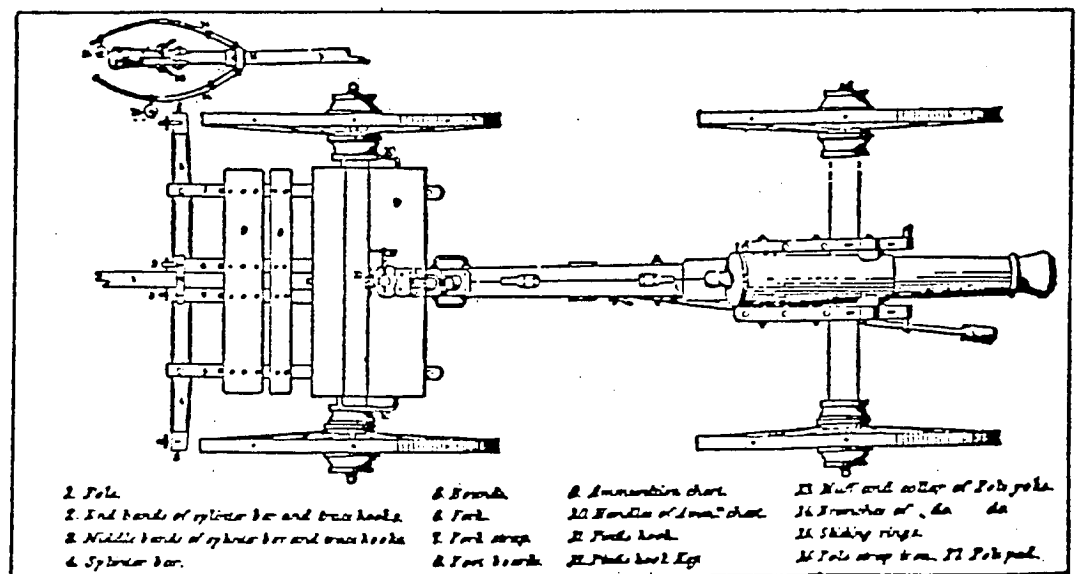
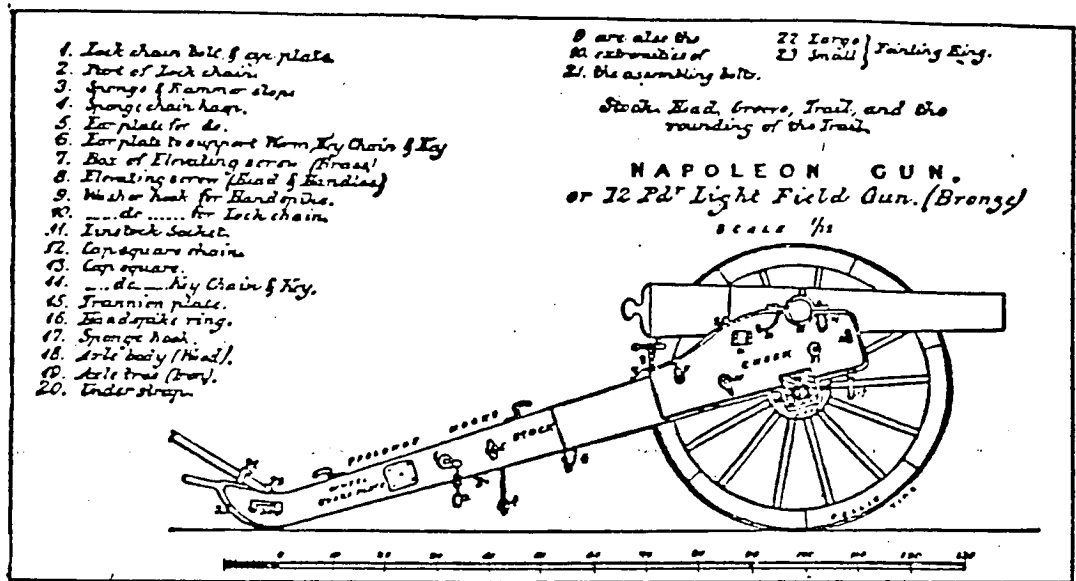
Front View



Plan View

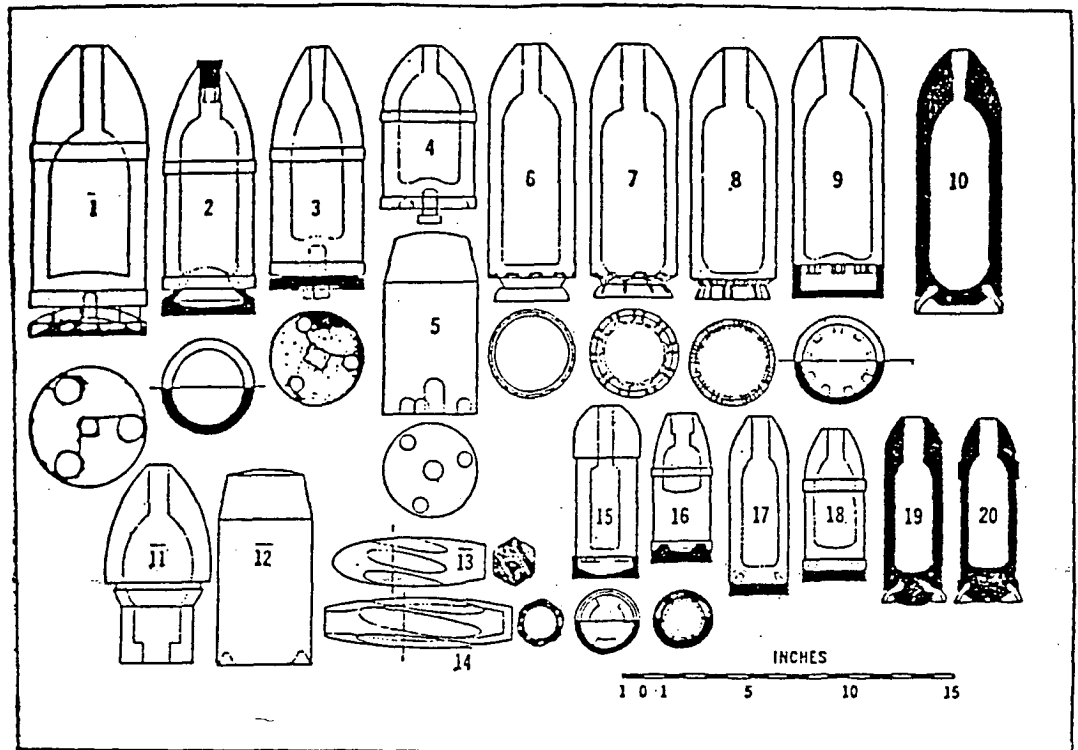
USS Spuyten Duyvil Plunging Torpedo Boat
Barnes, (1869:Appendix plate)





Napoleon 12-Inch Field Gun (M1849)
 Downey, (1952:19 & 551)

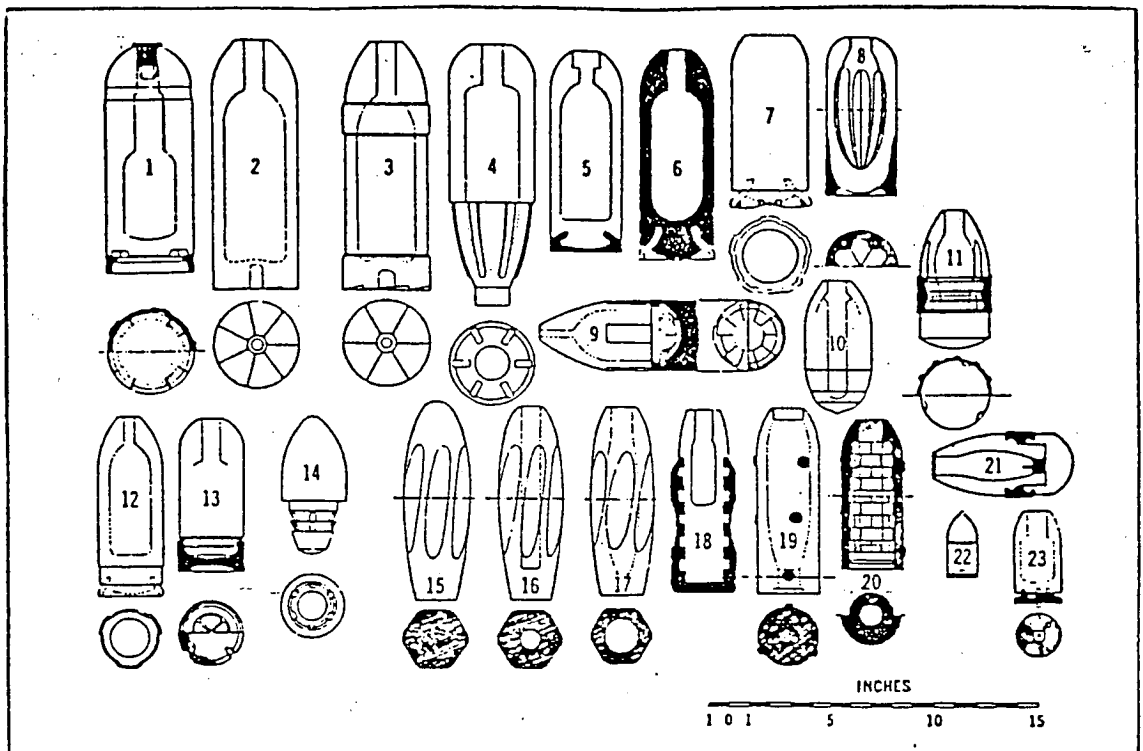
TYPES OF SHELLS AND FUSES



Confederate siege and field rifle projectiles: (1) 24-pdr., weight 57.5 lbs.; (2) 12-pdr., weight 29 lbs., copper cup; (3) 12-pdr., weight 28 lbs.; (4) 12-pdr., weight 21.5 lbs., plate missing; (5) 12-pdr., weight 32 lbs., plate missing; (6) 9-pdr., weight 25 lbs., copper ring missing; (7) 9-pdr., weight 25 lbs., copper ring missing; (8) 9-pdr., weight 25.5 lbs., copper ring missing; (9) 9-pdr., weight 26 lbs., copper ring, wooden fuze plug; (10) 9-pdr., weight 26 lbs., wrought iron cup, wooden fuze plug; (11) 18-pdr., weight 24 lbs. (defective); (12) 12-pdr., weight 40.5 lbs., solid wrought iron; (13) Weight 6.4 lbs.; (14) Weight 5.7 lbs.; (15) 3-pdr., weight 10 lbs.; (16) 3-pdr., weight 6.8 lbs.; (17) 3-pdr., weight 9 lbs.; (18) 3-pdr., weight 7 lbs.; (19) 3-pdr., weight 10 lbs.; (20) 3-pdr., weight 8 lbs. Classification: Class 1, Reed, wrought-iron cup (10, 19, 20); copper ring (2, 6, 7, 8, 9, 15, 16, 17, 18); Class 2, copper cup (1, 3, 4, 5); Class 3, copper "ratchet sabot"; Class 5, solid wrought iron (12); Class 6, Whitworth (13, 14); Class 9, Hotchkiss (11). (From H. L. Abbott's "Siege Artillery in the Campaigns against Richmond." Other Confederate artillery projectiles are shown in Fig. 6.)

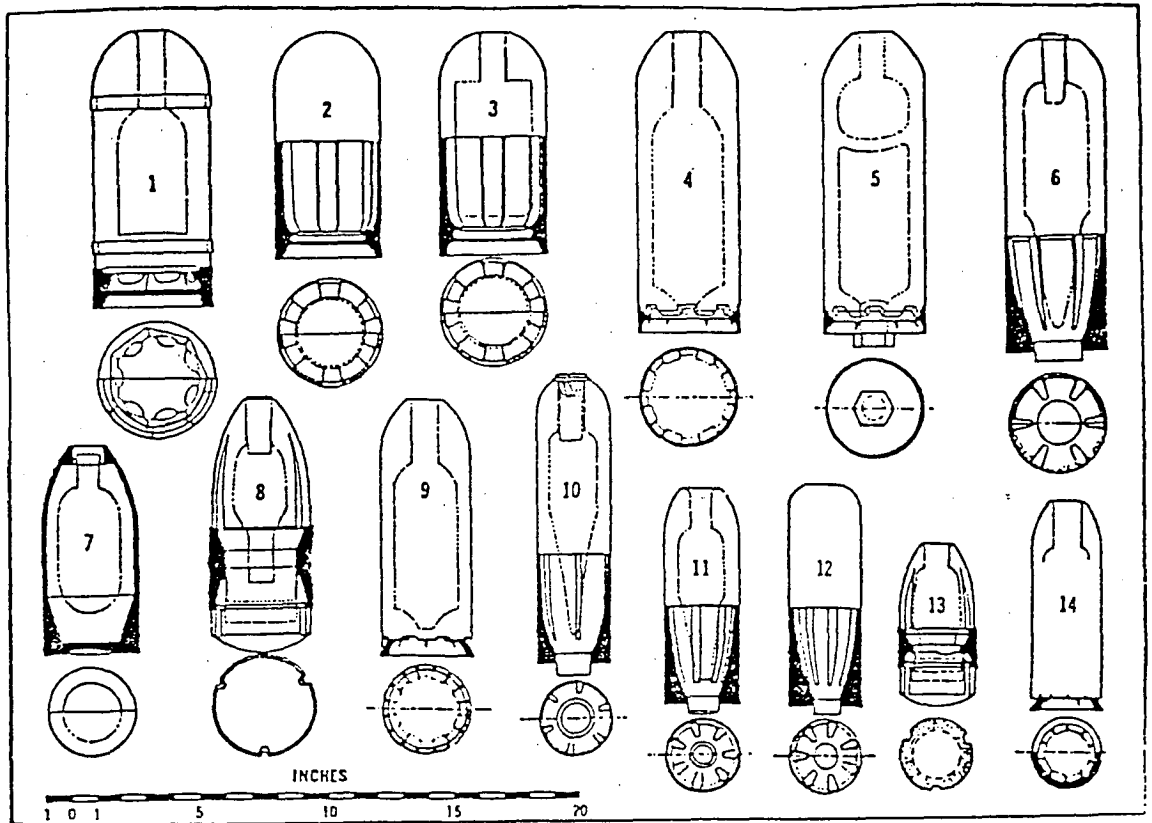
(Lewis, 1959:14, 15, 19 & 17)

TYPES OF SHELLS AND FUSES



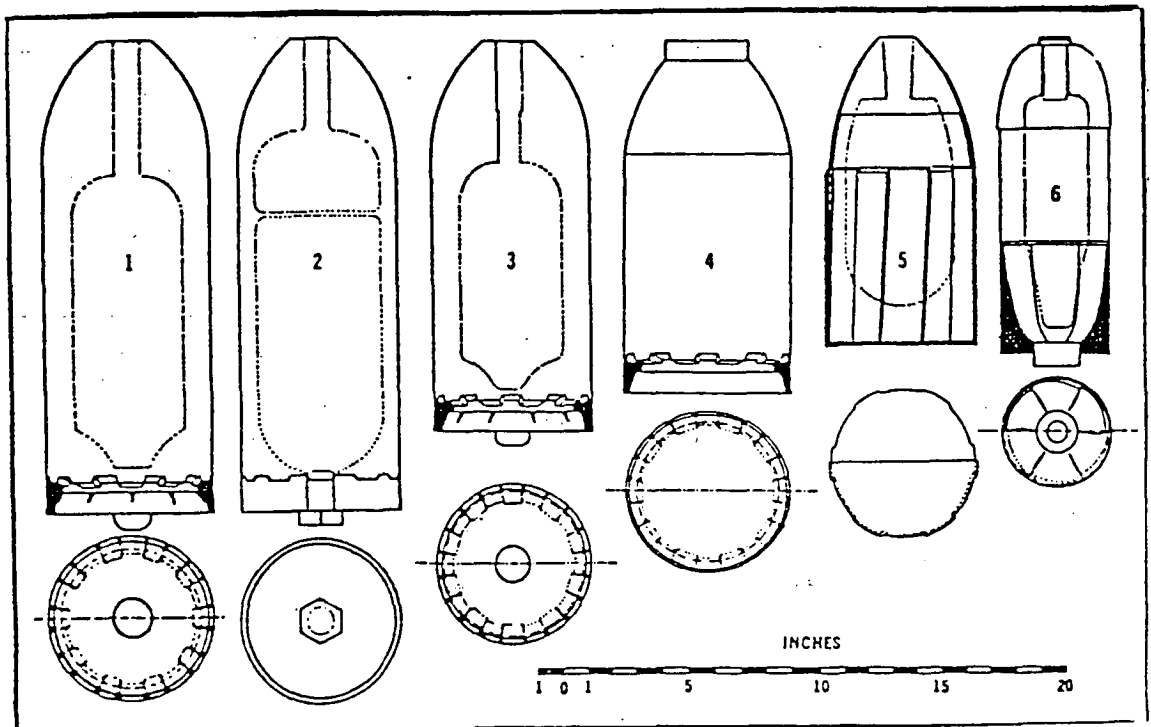
Confederate siege and field rifle projectiles: (1) 9-pdr., weight 28 lbs.; (2) 9-pdr., weight 24.5 lbs., sabot missing; (3) 9-pdr., weight 25 lbs., sabot missing; (4) 9-pdr., weight 24.5 lbs., sabot missing; (5) 6-pdr., weight 14.5 lbs.; (6) 6-pdr., weight 17.7 lbs., wrought-iron cup; (7) 6-pdr., weight 19.5 lbs.; (8) 6-pdr., weight 14.5 lbs.; (9) 4-pdr., weight 11.5 lbs.; (10) 4-pdr., weight 11.5 lbs., sabot missing; (11) 4-pdr., weight 9.5 lbs.; (12) 3-pdr., weight 8 lbs.; (13) 3-pdr., weight 8 lbs., lead fuze plug; (14) 3-pdr., weight 8 lbs., sabot missing; (15) 3-pdr., weight 13.3 lbs.; (16) 3-pdr., weight 12.1 lbs.; (17) 3-pdr., weight 9.5 lbs.; (18) 3-pdr., weight 12.3 lbs.; (19) 3-pdr., weight 10 lbs.; (20) 3-pdr., weight 10 lbs.; (21) 3-pdr., weight 9.3 lbs.; (22) Weight 1.1 lbs., ring missing; (23) Weight 3 lbs. Classification: Class 1, Reed wrought-iron cup (6, 7, 12), copper ring (1, 5, 22); Class 2, copper cup (23); Class 3, copper "ratchet sabot" (2, 3); Class 4, lead sabot (8, 9, 10, 13, 14); Class 6, Whitworth (15, 16, 17); Class 7, Armstrong, lead-coated (18), shunt (19, 20); Class 9, Hotchkiss (11, 21); Class 10, Schenkl (4). (Abbott's "Siege Artillery in the Campaigns against Richmond.")

TYPES OF SHELLS AND FUSES



U. S. siege and field rifle projectiles, 1864: (1) 11-pdr., weight 32.5 lbs.; (2) 11-pdr., weight 31 lbs.; (3) 11-pdr., weight 23 lbs.; (4) 9-pdr., weight 25 lbs.; (5) 9-pdr.; (6) 9-pdr., weight 24 lbs.; (7) 6-pdr., weight 13.2 lbs.; (8) 6-pdr., weight 19 lbs.; (9) 6-pdr., weight 16.5 lbs.; (10) 3-pdr., weight 16 lbs.; (11) 3-pdr., weight 7.8 lbs.; (12) 3-pdr., weight 9.2 lbs.; (13) 3-pdr., weight 9 lbs.; (14) 3-pdr., weight 9.2 lbs. Classification: Parrott, brass ring (4, 5, 9, 14); Schenkl, papier-mâché sabot (6, 10, 11, 12); Hotchkiss, compressed lead band (8, 13); Dyer, lead sabot (2, 3); Sawyer, lead sabot and lead-coated (7); Absterdam, lead sabot and bands (1). (From H. L. Abbott's "Siege Artillery in the Campaigns against Richmond.") See Figure 7 also.

TYPES OF SHELLS AND FUSES



U. S. siege and field rifle projectiles, 1864: (1) 32-pdr., weight 95 lbs.; (2) 32-pdr.; (3) 32-pdr., weight 81 lbs.; (4) 32-pdr., weight 92 lbs.; (5) 24-pdr. Sawyer, weight 41 lbs.; (6) 11-pdr., weight 26 lbs. Classification: Parrott, brass ring (1, 2, 3, 4); Schenkl, papier-mâché sabot (6); Sawyer, flanged and lead-coated (5); Absterdam, lead sabot (1). (Abbott's "Siege Artillery in the Campaigns against Richmond.")

CIVIL WAR SEIGE AND GARRISON
ARTILLERY

Seige and Garrison Artillery	Caliber Bore (in.)	Length Of Tube (in.)	Weight Of Tube (lb.)	Weight of Projectile (lb.)	Weight of Charge (lb.)	Range (Yards at 5 Degree Elevat)
4.5 Inch (MLR)	4.50	133.00	3450	33.00	3.50	2070
30-Pounder Parrott (MLR)	4.20	136.00	4200	29.00	3.75	2200
24-Pounder Gun (SB)	5.82	124.00	5790	24.00	6.00	1900
18-Pounder Gun (SB)	5.30	123.25	4680	18.50	4.50	1592
12-Pounder Gun (SB)	4.62	116.00	3120	12.30	4.00	1834
8-Inch Howitzer (SB)	8.00	61.50	2614	50.50	4.00	1241
Old Models -----						
Old 42-Pounder Rifle	6.80 ?	-	-	84.00	8.00	1650
Old 32-Pounder Rifle	6.40 ?	-	-	64.00	6.00	1650
Old 24-Pounder Rifle	5.82 ?	-	-	48.00	5.00	1670
30-Pounder Parrott Rifle	4.20	96.80	3550	30.00	3.50	1670
10-Inch Smooth Bore	10.00	120.00	12000	128.00	20.00	1740
8-Inch Smooth Bore	8.00	95.00	6000	68.00	10.00	1740

**CIVIL WAR SEA COAST
ARTILLERY**

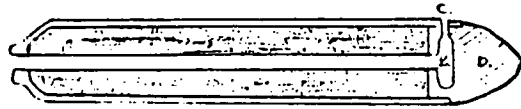
Sea Coast Artillery	Caliber Bore (in.)	Length Of Tube (in.)	Weight Of Tube (lb.)	Weight of Projectile (lb.)	Weight Of Charge (lb.)	Range	Elevation (Degrees)
32-Pounder Gun (SB)	6.40	125.2	7200	32.60	8	1922	5.00
42-Pounder Gun (SB)	7.00	129	8465	42.70	10.5	1955	5.00
8-Inch Columbiad (SB)	8.00	124	9240	65.00	10	1813	5.00
10-Inch Columbiad (SB)	10.00	126	15400	128.00	18	1814	5.00
15-Inch Columbiad (SB)	15.00	182	50000	c./350	40	5730	5.00
20-Inch Rodman (SB)	20.00	190	117000	1080.00	100	6160	20.35
100-Pounder Parrott	6.40	151	9700	70-100	10	2370	5.00
200-Pounder Parrott	8.00	159	16300	132-175	16	2000	5.00
300-Pounder Parrott	10.00	173	26500	230-250	25	2500	10.00
80-Pounder Whitworth (MLR)	5.00	118	8582	80.00	10	13665	10.00
70-Pounder Armstrong (BLR)	6.40	110	6903	79.00	10	2183	5.90
8-Inch Blakely (MLR)	8.00	156 (Bore)	17000	200.00	20	2000	5.00
150-Pounder Armstrong (MLR)	8.50	120	15737	150.00	20	2200	5.00
12.75-Inch Blakely (MLR)	12.75	192	54000	700.00	50	5000	15.00

**CIVIL WAR SMOOTH BORE
ARTILLERY**

Smooth Bore Artillery	Caliber Bore (in.)	Length Of Tube (in.)	Weight Of Carriage (lb.)	Weight of Tube (lb.)	Weight of Projectile (lb.)	Weight of Charge (lb.)	Range (Yards at 5 Degree Elevat.)	Total Gun Weight (lb.)
6-Pounder M1841-1844	3.67	60.00	900	884	6.10	1.25	1523	-
12-Pounder M1841-1844	4.62	78.00	1175	1757	12.30	2.50	1663	-
12-Pounder Howitzer M1841-1844	4.62	53.00	900	788	8.90	1.00	1072	3214
12-Pounder Mountain Howitzer	4.62	33.00	157	220	8.90	1.00	900	507-970
24-Pounder Howitzer M1841-1844	5.82	65	1128	1318	18.40	2.00	1322	4036
32-Pounder Howitzer M1841-1844	6.40	75.00	1175	1920	25.60	2.50	1504	4575
12-Pounder Napoleon M1857	4.62	66.00	1128	1227	12.30	2.50	1619 or 1680	3865 (Caisson 3811)

**CIVIL WAR NAVAL
ARTILLERY**

Naval Artillery	Caliber Bore (in.)	Length Of Bore (in.)	Weight Of Total Gun (lb.)	Type Of Projectile	Weight of Projectile (lb.)	Weight of Charge (lb.)	Range (Yards at 5 Degree Elevat.)
<u>Smooth Bores</u>							
15-Inch	14.50	130.00	42000	330-352	Shell	35	1700
11-Inch	10.85	132.00	15700	135.50	Shell	15	1712
10-Inch	9.85	120.00	12000	101.50	Shell	12.5	1740
9-Inch	8.85	107.00	9200	70.00	Shell	10	1710
8-Inch/64-Pounder	7.85	95.00	6000	52.70	Shell	7	1657
32-Pounder Howitzer	6.25	69.00	3000	32.00 26.00	Shot & Shell	4 4	1469 1460
24-Pounder Cohorn How.	5.80	58.00	13000	17.50	Shell	2	1270
12-Pounder Cohorn How.	4.60	55.00	760	8.50	Shell	1	1085
<u>Rifled Guns</u>							
150-Pounder Parrott	8.00	136.00	16500	152.00	Shell	16	2000
100-Pounder Parrott	6.40	130.00	9700	70-100 70-100	Shot & Shell	10 10	2000 2000
60-Pounder Parrott	5.30	105.00	5360	55.00	(Shot)	6	2100
30-Pounder Parrott	4.20	96.80	3550	25-30	(Shot)	3.25	1670-2200



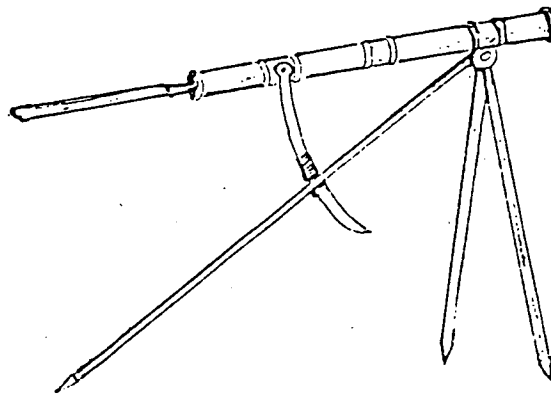
Hale War Rocket
New type, two rotation orifices
at centre of gravity shell.



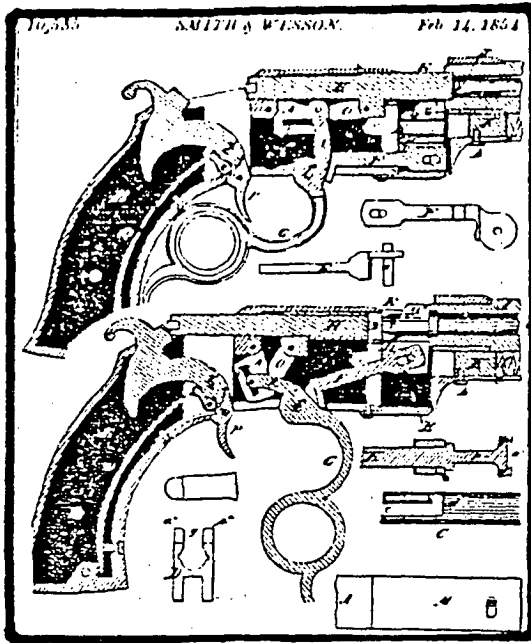
Hale War Rocket
Introduced c. 1855. Rotation
orifice in head.
(a) bore and vent
(b) recess in base of head
(c) tangential vents-3
(d) head solid in the centre



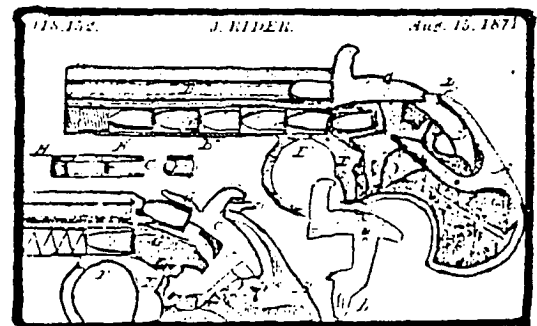
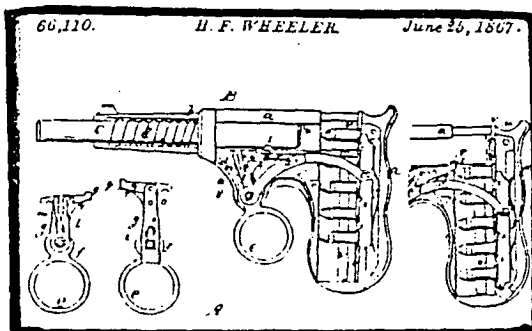
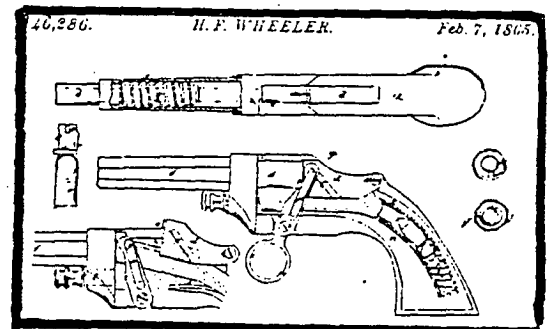
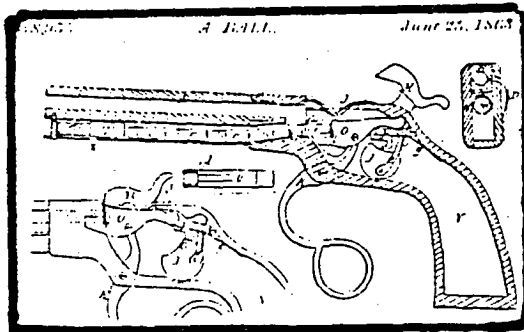
Congreve War Rocket
Guidance by stick attached at rear.



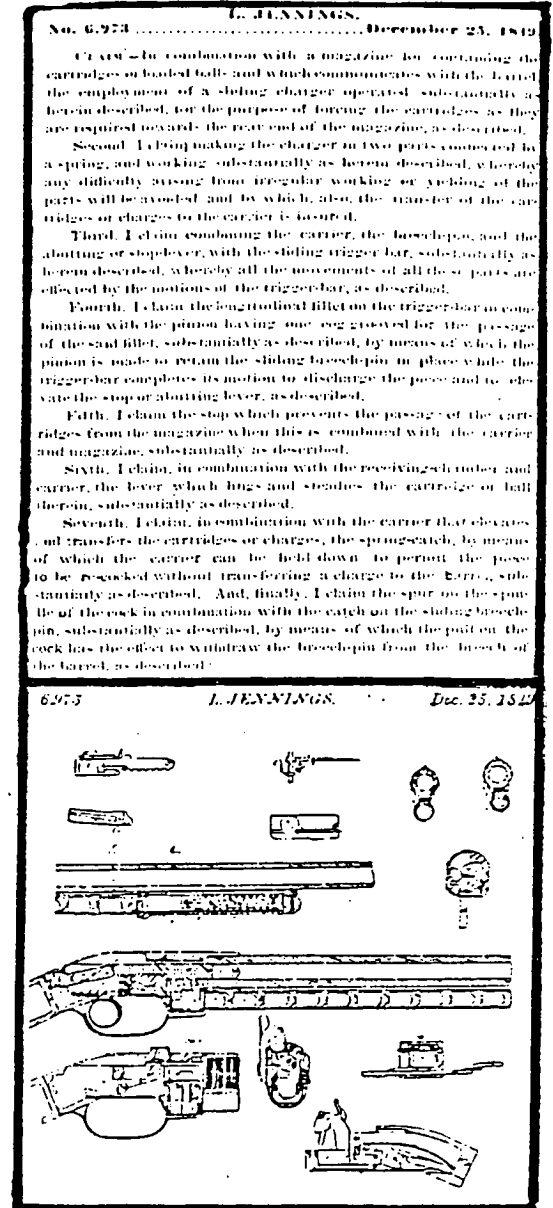
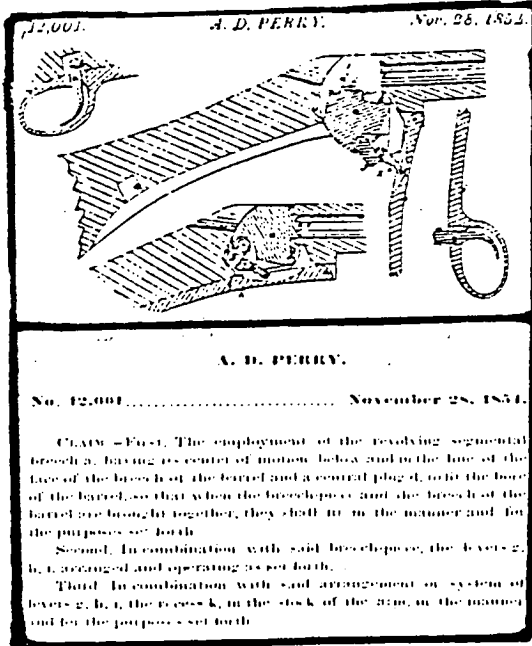
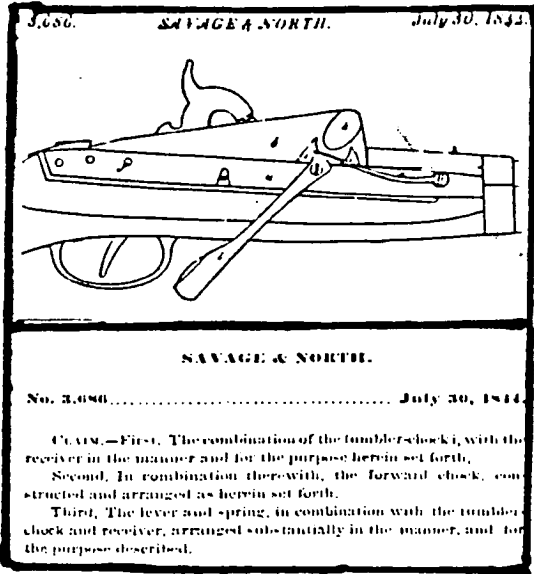
Congreve War Rocket Launcher
(Loaded)



Evolution of Repeating Pistol Designs



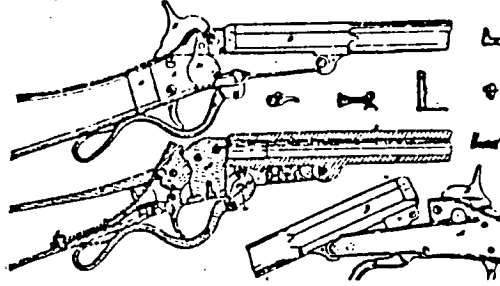
Evolution of The Breech Loader



56,364.

E. MAYNARD.

Dec. 6, 1865.



EDWARD MAYNARD.

No. 20,364. December 6, 1859.

CLAIM.—First, The peculiar manner of connecting the barrel to the breech piece, viz: the hook *c*, on the underside of the barrel, taking hold of the pin *f*, or the equivalent thereof, at the front end of the breech piece, while the link *U*, the lever *H*, and the joint pins of said link and lever are arranged in such a manner, with relation to the slot in the breechpiece and the ears on the underside of the butt of the barrel, as to form a triple jointed and compound leverage connection between the breechpiece and the butt of the barrel, of such a character that a barrel can be instantly thrown from a firing position to a loading position, and *vice versa*; and also of such a character that the barrel can be easily and quickly detached from the breechpiece or be securely united therein, substantially in the manner set forth.

Second, I also claim the combination of the metallic block *b*, the screw *a*, and the screw *z*, with each other and with the front portion of the breechpiece in such a manner, with relation to the shoulder *d*, on the underside of the barrel, that the joint between the butt of the barrel and the abutment of the breechpiece can be tightened or loosened, substantially in the manner set forth.

Third, I also claim retaining the pivot pin *w*, in its position within the breechpiece by means of the overlapping head of the screw *al*; but this I only claim when the longitudinal groove *x* in one side of a portion of the length of said pivot pin is so located that when the pin is turned to the position shown in fig. 12, or any other previously determined position, it may be drawn out far enough (and only far enough) to detach the said pin from its hold upon the lever *H*, and thereby allow the barrel to be separated from the breechpiece substantially in the manner set forth.

Fourth, When the pivot pin *w*, is retained in its position within the breechpiece by the overlapping head of screw *al*, in such a manner that it can be loosened by partially turning the same upon its axis, I also claim the arm *bt*, upon the outer end of said pin which enables it to be readily turned upon its axis, and partially withdrawn from its place without any mechanical assistance, substantially as set forth.

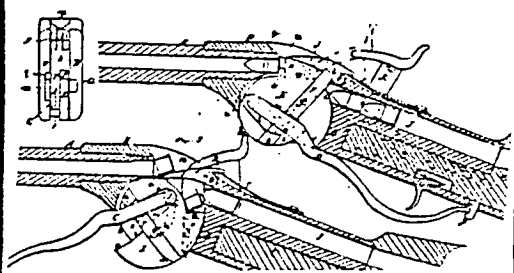
Fifth, When the barrel is connected to the breechpiece in the within described manner, I also claim the producing of a tight joint between the butt of the barrel and the abutment of the breechpiece by combining therewith a flange bottomed metallic cup, substantially as set forth.

Sixth, I also claim giving the opposite faces *r*, *r*, of the butt of the barrel such a shape that the flange bottomed metallic cup *y*, can be easily taken hold of by the thumb and finger of the free hand of the user when the barrel is thrown into the loading position, substantially as set forth.

27,393.

C. M. SPENCER.

Mar. 6, 1860.



C. M. SPENCER.

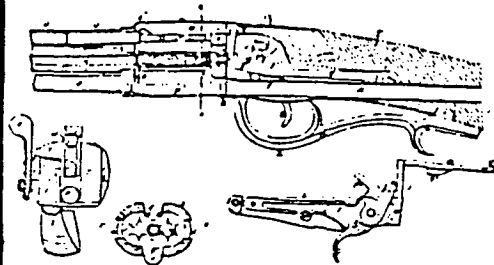
No. 27,393. March 6, 1860.

CLAIM.—First, The combination of the rolling breech *E*, the lever *G*, and sliding locking-bolt *F*, the whole fitted and applied substantially as set forth.

Second, The slide *H*, applied to the rolling breech and operating in combination with the hammer, substantially as and for the purpose specified.

Third, The combination of the serrated projection *u*, in the rolling breech, and the tongue *J*, applied and operating substantially as described, within the opening in the breech-supporter.

32,316. L. SIBERT. May 14, 1861.



LORENZO SIBERT.

No. 32,316. May 14, 1861.

CLAIM: First, The combination of the series of magazine tubes B, with the barrel A, and breech D, substantially in the manner and for the purpose described.

Second, The conveyor G, when arranged and operating substantially as set forth.

Third, An open breech, so constructed as to permit the unobstructed passage of a cartridge directly through the same from top to bottom, substantially in the manner described.

Fourth, The combination of the fluted rollers F, F', or their equivalent, for the purpose of forming an open chamber to receive and hold the cartridge, and discharge it when exploded.

Fifth, The combination of the magazine tube B, conveyor G, hammer J, and fluted rollers F, F', or their equivalent, substantially as set forth for the purpose set forth.

Sixth, Expelling the empty cartridge case from the discharge chamber by means of the succeeding cartridge, substantially in the manner described.

Seventh, Discharging the empty cartridge cases automatically into a chamber in the stock of the gun, where they may be preserved for future use.

Eighth, Holding the loaded cartridge at the moment of explosion in an open chamber in such manner that the cartridge itself shall form a prolongation or extension of the bore of the gun.

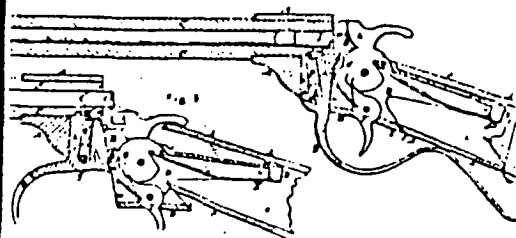
Ninth, So arranging the fluted rollers F, F', that the separate diameter of the loaded cartridge lying thereon shall project into the plane of the tube B, to prevent the escape of more than one cartridge therefrom at a time.

Tenth, The lock, composed of the hammer J, no-spring I, trigger S, trigger spring V, and cocking-lever L, arranged substantially in the manner described, in combination with the conveyor G, for the purpose set forth.

Eleventh, The combination of the combining tube H, and fluted rollers F, F', or their equivalent, substantially in the manner and for the purpose described.

Twelfth, The guides G, in combination with the breech D, and fluted rollers F, F', or their equivalent, substantially in the manner described, for the purpose set forth.

33,631. C. H. BALLARD. Nov. 5, 1861.



C. H. BALLARD.

No. 33,631. November 5, 1861.

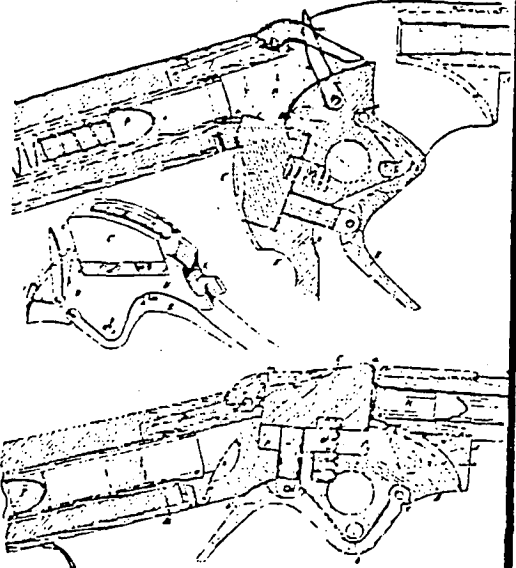
CLAIM: First, The breech B, composed of a long block with shoulders a, b, fitted to corresponding shoulders c, f, within the breech supporter A, and arranged in combination with a lever D, to move upward and downward as well as longitudinally, within a parallel slot cavity in the said supporter under the control of guides d, above and below its rear portion, all substantially as specified.

Second, The arrangement of all the parts of the lock of breech loading rifle or other small arm within a slot in the movable breech substantially as specified.

Third, The bolt E, having a protuberance e, applied in combination with the lever D, the breech, and the hammer, for the purpose of bringing the hammer to halfcock by the act of opening the breech, substantially as specified.

Fourth, Combining the lever E, with the hammer H, by means of a horn n, or its equivalent, substantially as and for the purpose specified.

36,062. C. M. SPENCER. July 29, 1862.



CHRISTOPHER M. SPENCER.

No. 36,062. July 29, 1862.

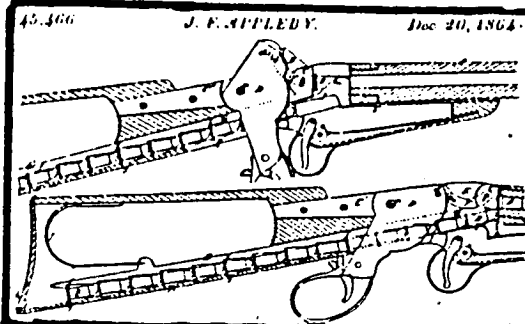
(Revised April 12, 1864)

IMPROVEMENT.

CLAIM: First, The compound breech, consisting of the pieces B, and C, constructed, operated and operating substantially in the manner described.

Second, The combination with the compound breech B, C, of the guard lever G, substantially in the manner and for the purpose set forth.

Third, The lever G, arranged and operated substantially as described.



JOHN F. APPLEBY.

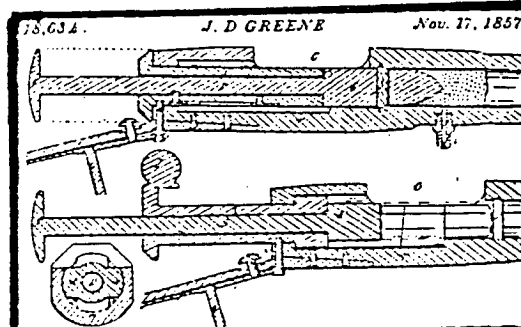
No. 45,400. December 20, 1864.

This arm belongs to the class provided with a magazine of cartridges, which are automatically fed to the chamber by the movement of the guard lever. The reciprocating breech-piece is attached to a serrated rod running back into the stock, each serration holding a cartridge and moving one forward at each closing of the breech. A spring carrier or cartridge-lifter brings the forward cartridge up in line with the chamber at each opening of the said breech.

CLAIM.—The combination of the cartridge ratchet rod G, with the breech-piece C, substantially in the manner and for the purpose herein shown and described.

Also, the combination of the spring cartridge-lifter I, with the breech-piece C, and ratchet-rod G, substantially in the manner and for the purpose herein shown and described.

Sliding Breech Loading Bolt Action



J. D. GREENE.

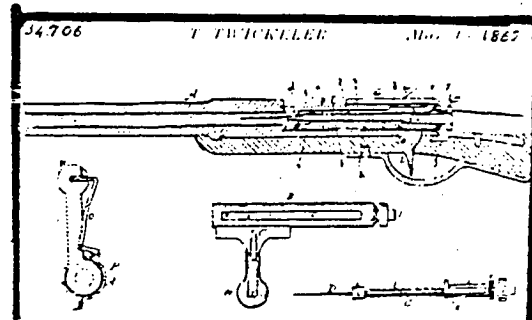
No. 18,634. November 17, 1857.

In this improvement, the barrel A, is extended back to form a loading chamber T, into which there is an opening G, for the insertion of the cartridge. Through the rear of the chamber passes a revolving sliding plunger C, and through the center of this plunger a rod B, which carries at its forward end a breech-plug E, and at its rear end a button F. The plunger is also furnished with a ball or button I, by which it is manipulated, and carries two projecting ears d, which, when the plunger is in the position seen in the engravings, enter recesses e, in the walls of the chamber, and rest against the shoulders r, by which the plunger is revolved 90°, the ears d, clear the shoulders r, and the plunger may be drawn back.

CLAIM.—First, The groove i, or its equivalent, operating in connection with the wad at the rear of the cartridge, in the manner substantially as set forth. I do not claim a sliding breech-plug, secured to the barrel by ears and shoulders, as such device does not constitute my present invention.

Second, The sliding breech-plug E, in combination with the revolving plunger C, operating in the manner set forth.

Third, The ball C, and stop V, operating in the manner set forth, to interrupt the movement of the plunger, as described.

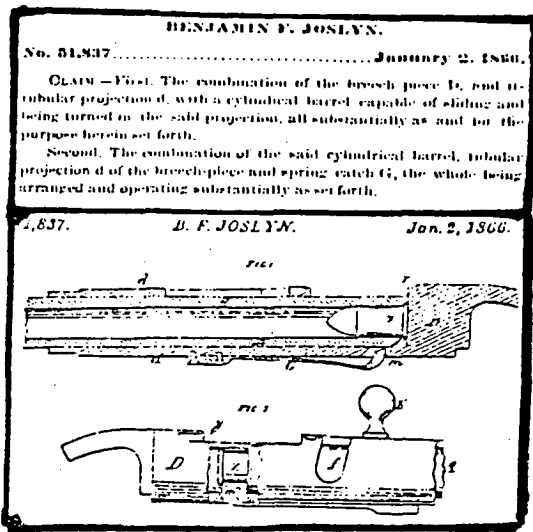


THEODORE TWICKLER.

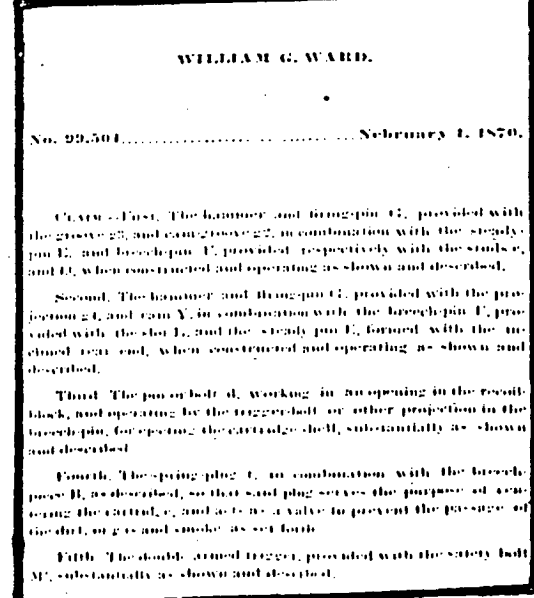
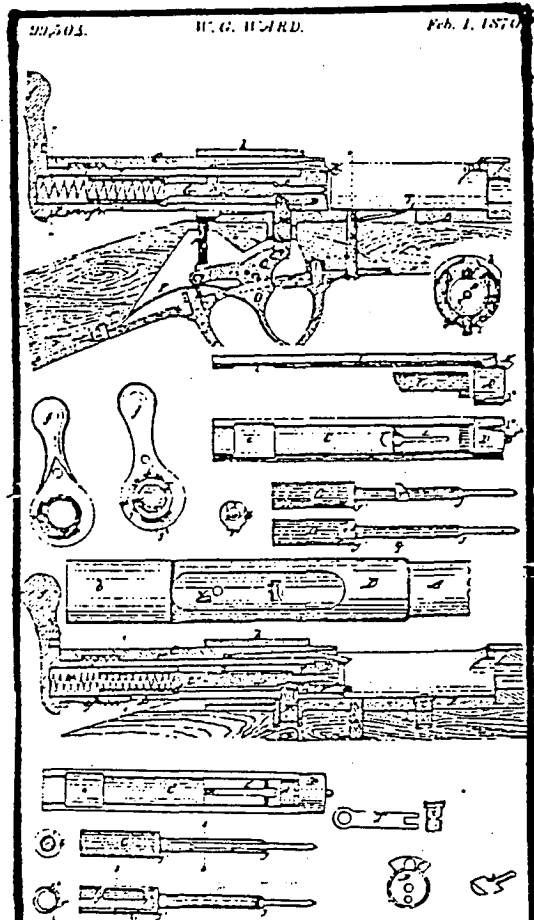
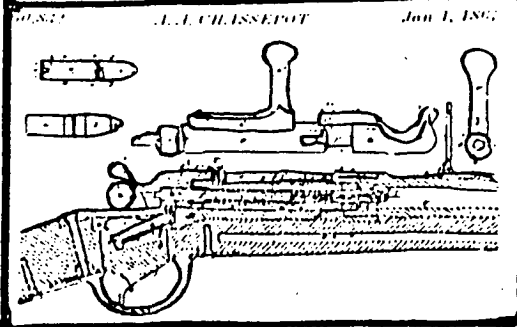
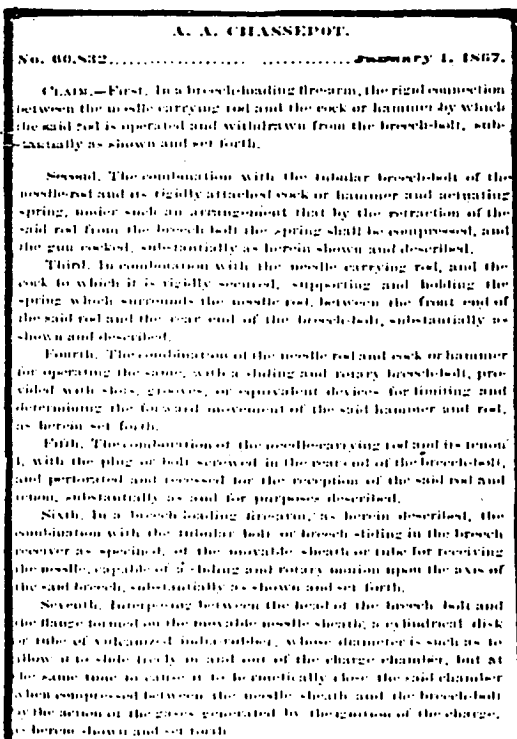
No. 34,706. March 18, 1862.

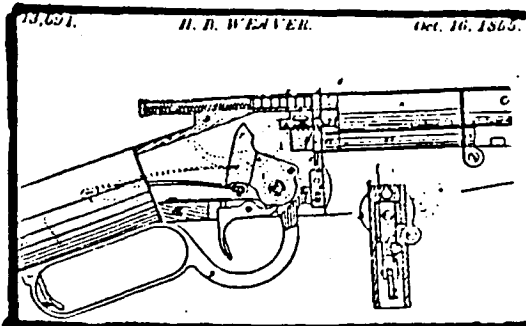
CLAIM.—The arrangement of the catch-lever O, the spring L, and the thumb-lever I, furnished with a stud or shoulder V, as set forth, with respect to the needle-bar carriage, and so as to operate in holding the spring L, in a compressed state, in manner and under circumstances described.

Sliding Longitudinally Forward



Breech Sliding Backward (Longitudinally Operated By Hand)





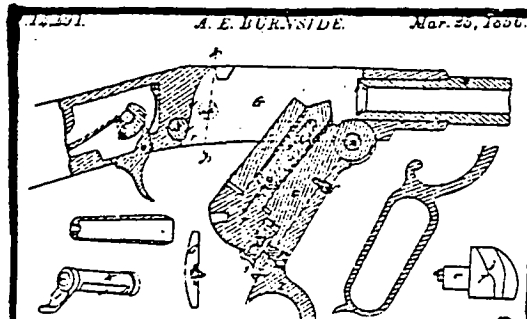
H. B. WEAVER.

No. 13,691.....October 16, 1865.

CLAIM.—First, Combining the hammer with the laterally-swinging chamber, for the purpose of effecting the simultaneous opening of the chamber and cocking of the hammer by means of the lever D, the pin k, slide d, and lever arm e, all operating substantially as described, whether the slide d, be a priming slide, or simply employed to connect the chamber A, with the lever D.

Second, Combining the priming slide d, with the lever D, and the hammer F, by means of a pin l, attached to the lever, working in a slot n, in the slide or link attached thereto, so that the lever D, will draw back the hammer before moving the slide far enough to allow the pin b, or its equivalent, through which the hammer strikes the gap, to move out of the receiving hole in the slide before the slide is acted upon by the lever substantially as set forth.

Swinging on Longitudinal Pin



A. E. BURNSIDE.

No. 14,491.....March 25, 1866.

(Issued March 10, 1867.)

Reissue No. 1,429—

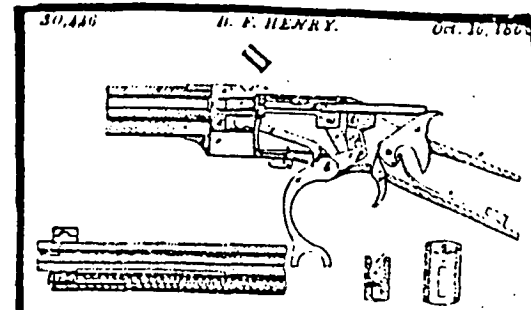
CLAIM.—First, The movable cartridge-box, so arranged that it may be brought up to abut against the end of the gun barrel, with the orifice of its chamber coincident with that in the rear of the barrel, and carried away from the barrel for the purpose of loading, substantially as set forth.

Second, In combination with the movable cartridge-block abutting against the end of the barrel, enlarging the ends of the barrel and the cartridge-chamber, as described for the purpose set forth.

Third, The conical cartridge-chamber, operating as set forth, for the purpose described.

Fourth, The sliding breech-pin, operating as set forth, for the purpose described.

Fifth, The projection in the rear of the breech-pin, for the purpose of starting the pin forward as the cartridge-block is withdrawn.



H. F. HENRY.

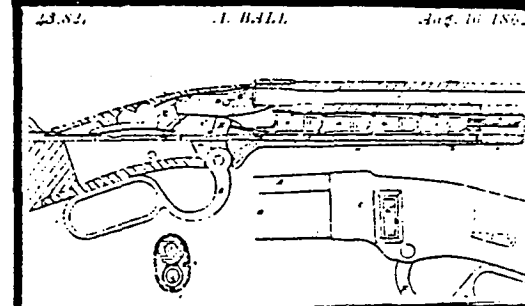
No. 30,446.....October 16, 1865.

(Released December 8, 1865.)

CLAIM.—First, In combination with the hollow breech-pin, the spring-catch m, on the breech pin, and the piston, arranged for central or rim-fire, or both, substantially as and for the purpose set forth.

Second, In combination with the carrier-block E, and the spring-catch m, placed on top of the breech-pin L, the so forming of the top of said carrier-block near the rear end, as shown at d, fig. 4, as to strike the cartridge forward of the centre, and thus raising the forward end of the cartridge, while the rear end is held down by the spring-catch, tripping it over and freeing it from the spring, and ejecting it from the gun, substantially as described.

Swinging & Tilting Bolt (Sliding Backward & Downward)



ALBERT HALL.

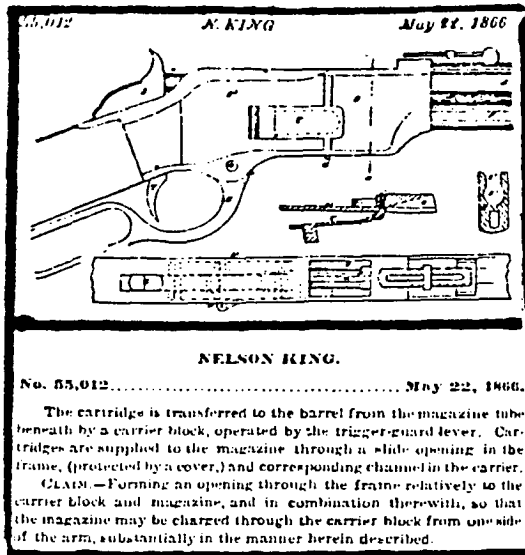
No. 43,827.....August 16, 1861.

CLAIM.—First, The combination of the rack bar c, the spring-pressor F, or its equivalent, and the impelling and retaining pawls G, H, the whole being applied to the magazine B, and the trigger-guard lever E, and so to operate together and with the charging carriage, substantially as specified.

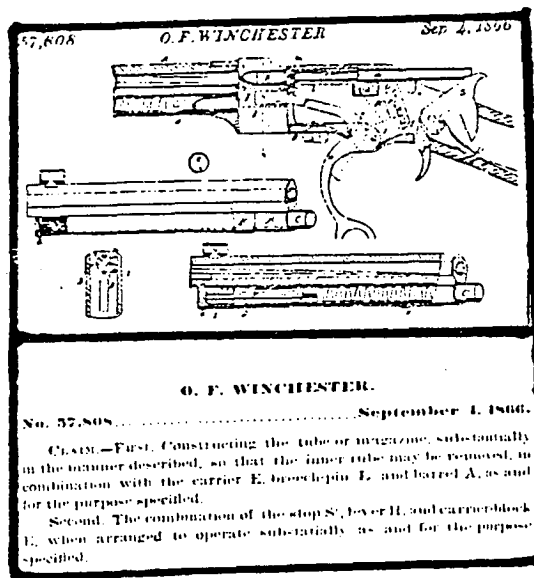
Second, The combination of the pawl-elevator I, with the pawls G, H, and the rack bar c, and spring-pressor F, when applied to a magazine B, and trigger-guard lever E, substantially in manner and so as to operate as specified.

Third, The arrangement of the pawl-spring L, with reference to the two pawls G, H, whereby it is caused to operate both of them.

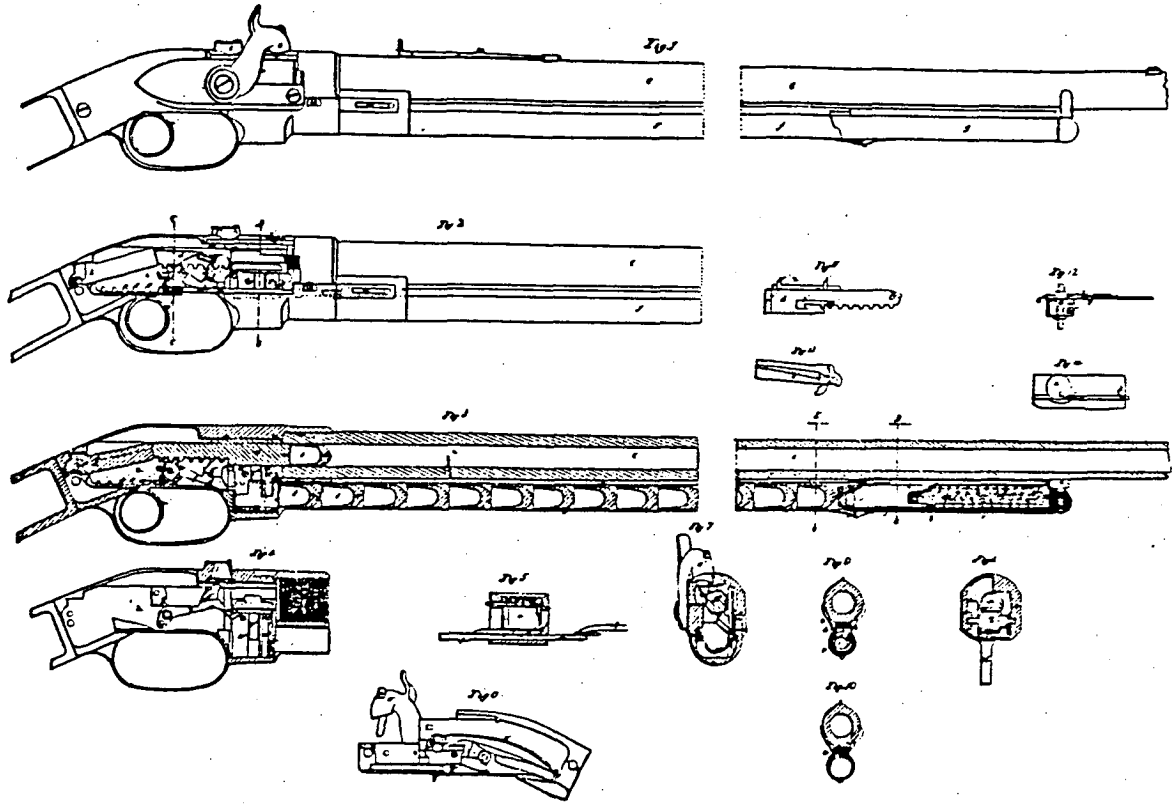
Fourth, The combination of the magazine cover R, and its band or attachment S, with the separate tubular magazine B, and the barrel A.



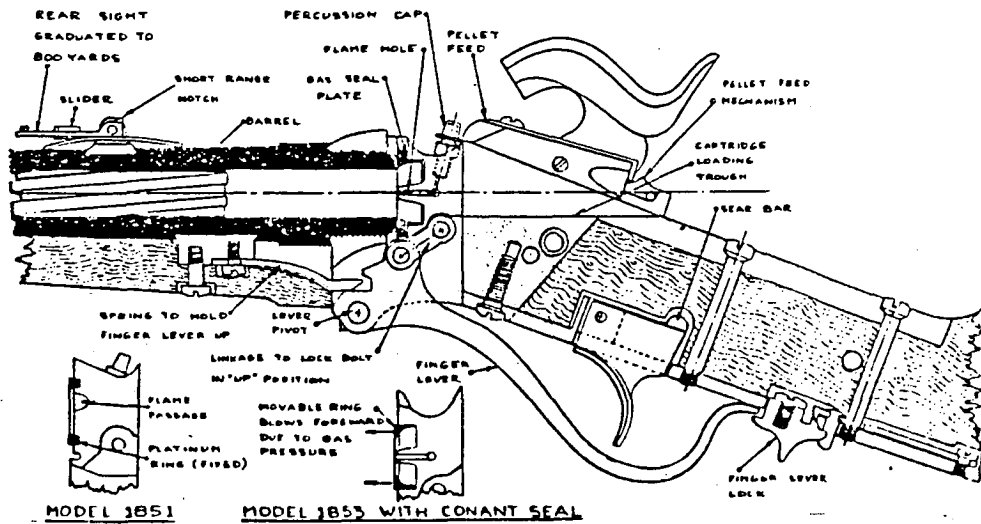
Breech Sliding Backward
(Operated By Lever)



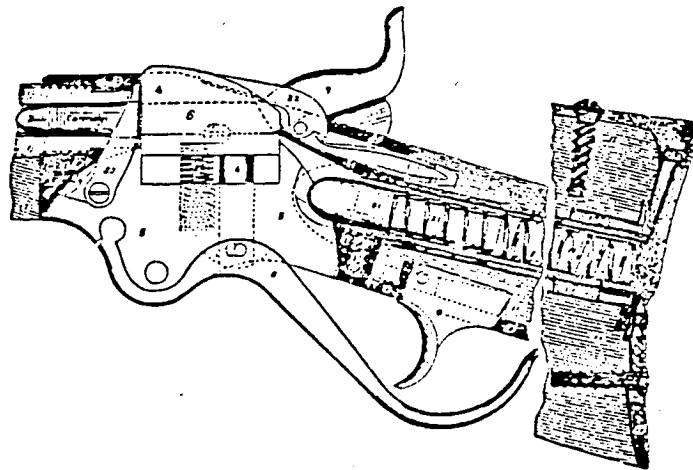
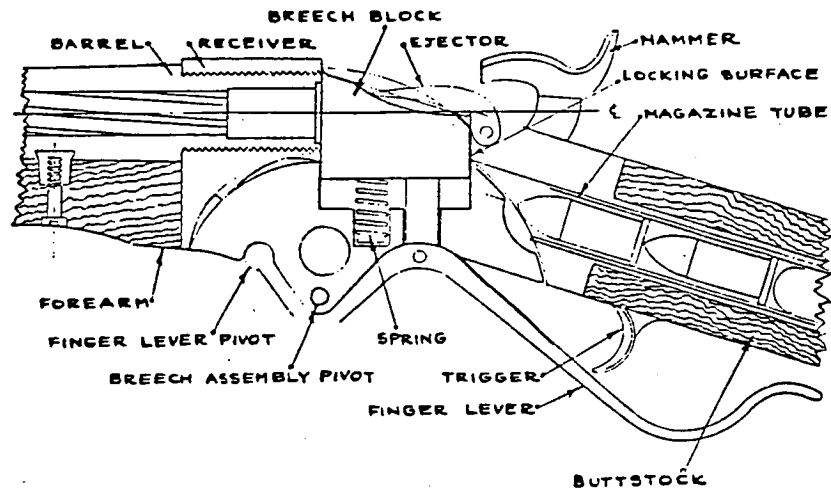
Volcano Repeating Rifle



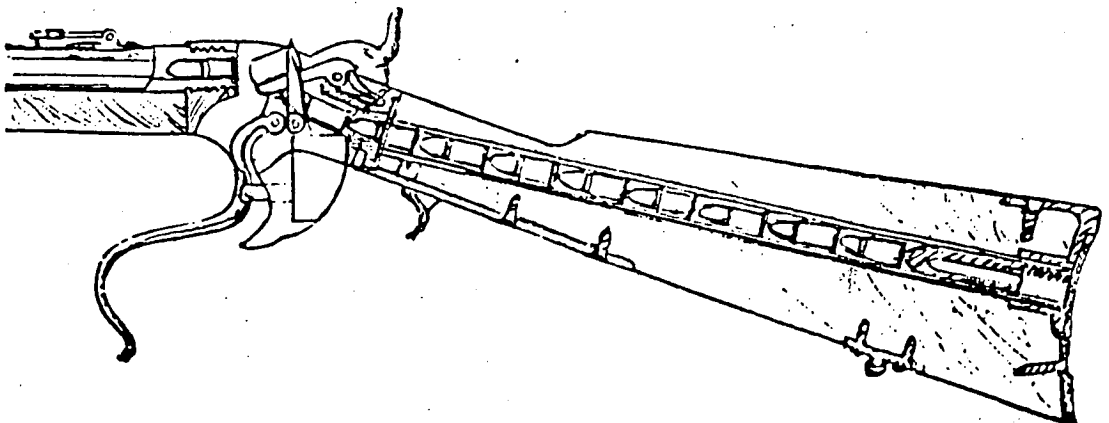
Model 1851 Sharps



Spencer Crossectional View
Of Mechanism (1865 Spencer
Catalogue)



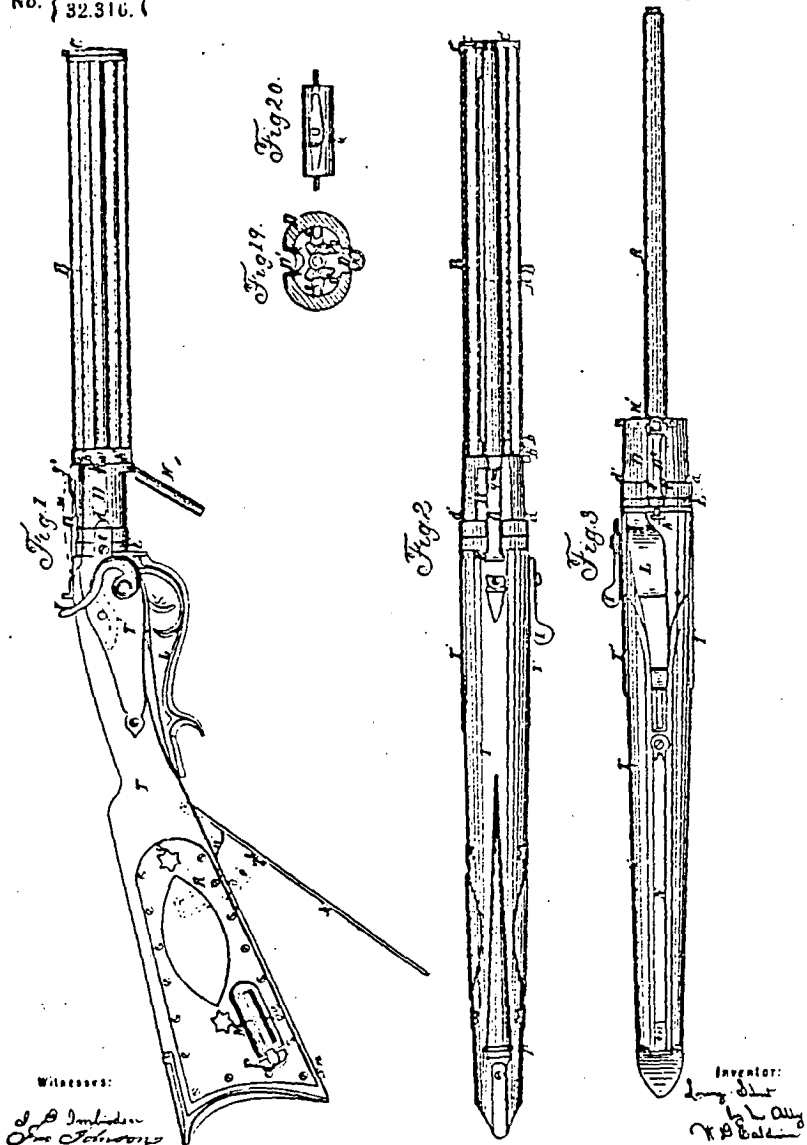
Spencer (Breech Open)



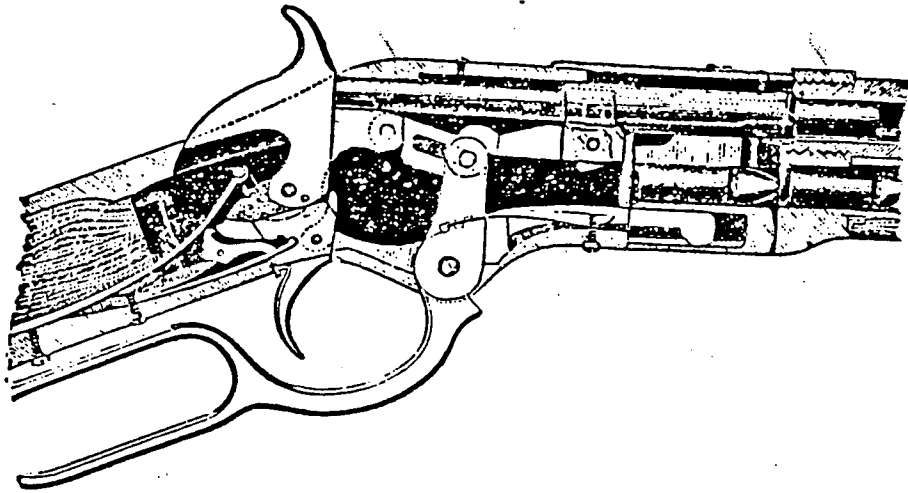
Sibert Magazine Fed Fire Arm
Fuller & Stuart, (1944:206, plate 20)

No. } 1,812, (
 32,316. (

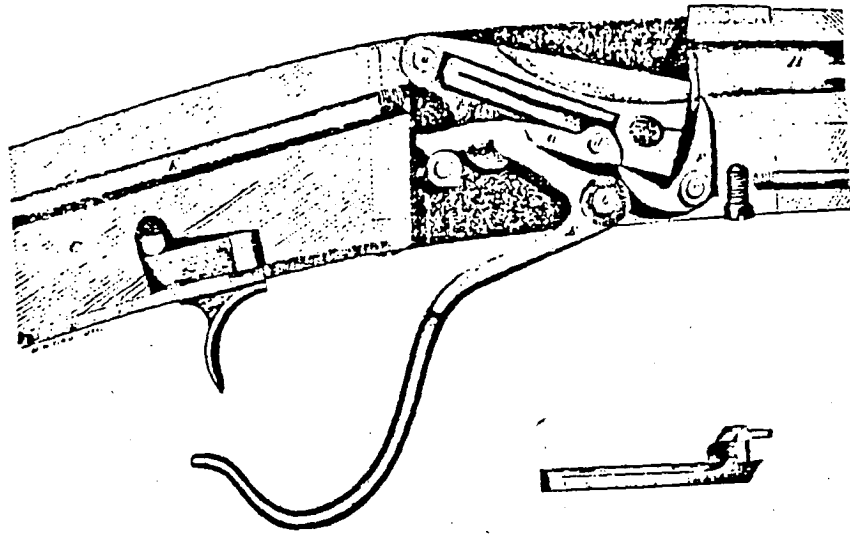
Patented May 14, 1861.



Winchester Model 1865

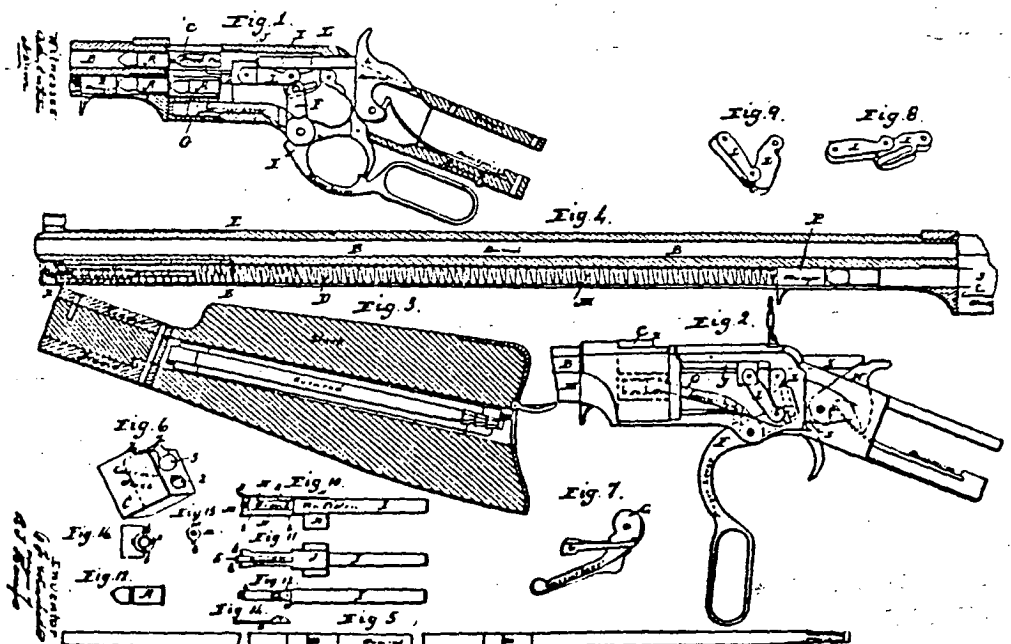


Peabody Crossectional View with
Operation Open
(Patent No. 35947 issued,
July 22, 1862)

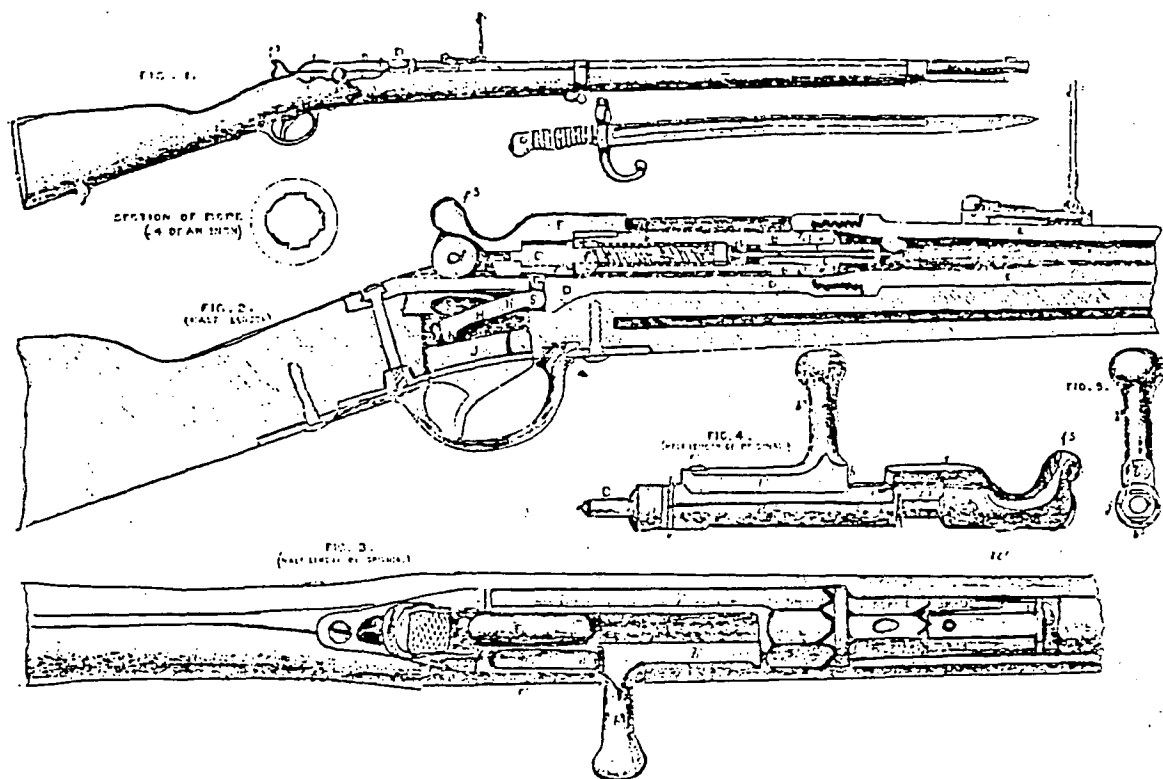


Scientific American (Vol.12[4], January 21, 1865)

Henry Magazine Fed Repeating Rifle
(Patent No. 30446 issued
October 16, 1860)

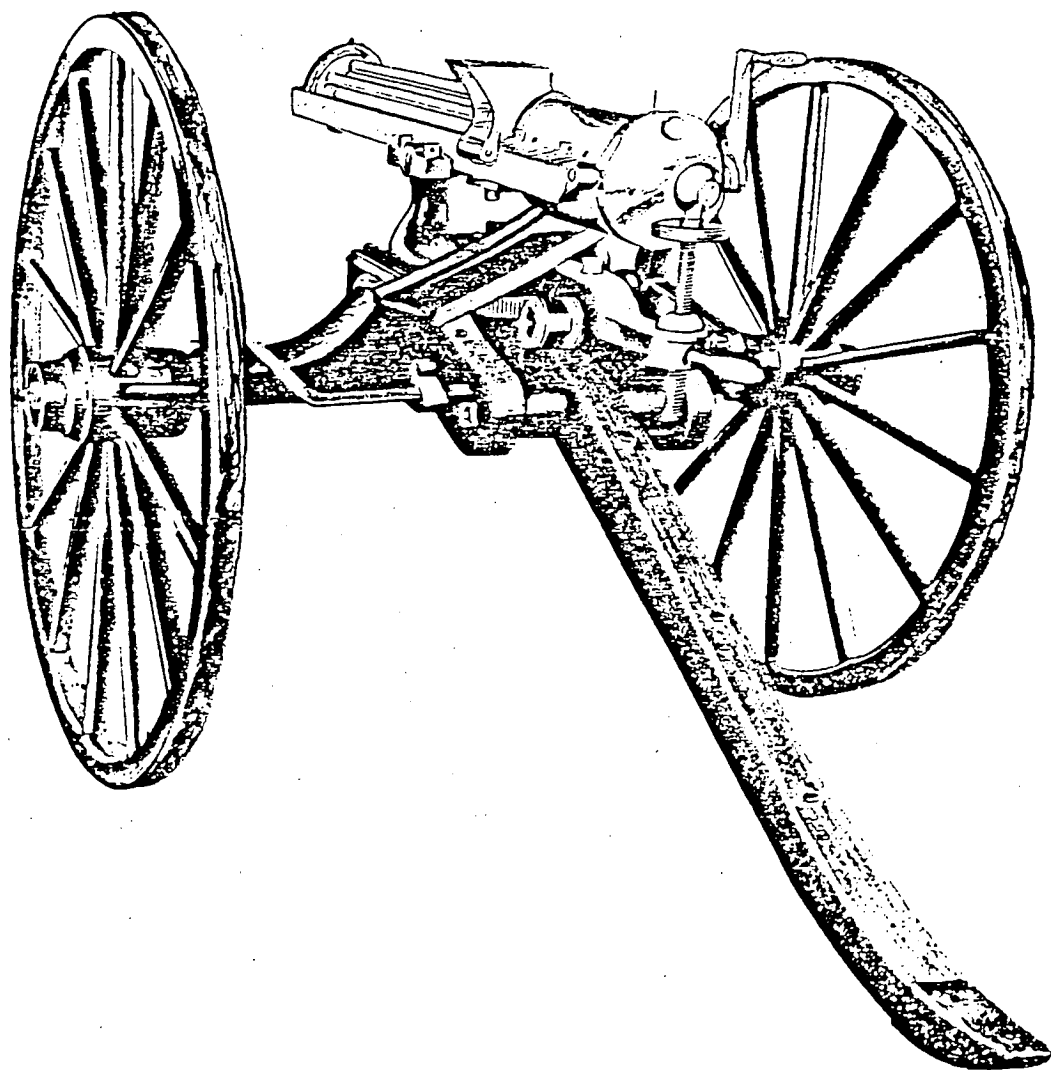


French Chassepot (Illustrated London News, March 1867)

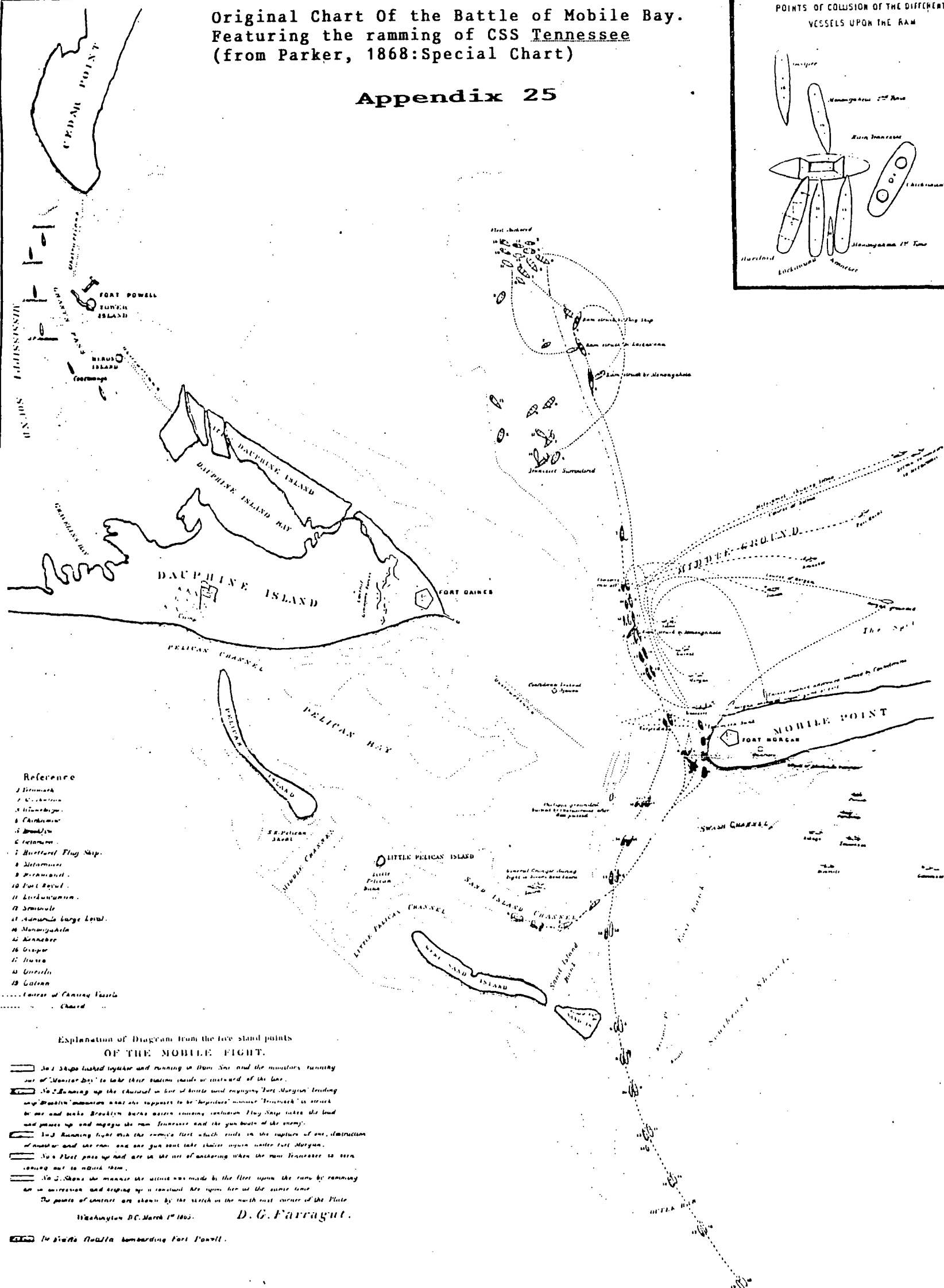


Appendix 24

Gatling Gun Model 1864
(Hogg & Batchelor 1974:113)



Appendix 25



AUGUST 5TH 1864.

Appendix 25